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Revision 1

**WELLS G & H SITE
REMEDIAL INVESTIGATION REPORT
PART I
WOBURN, MASSACHUSETTS**

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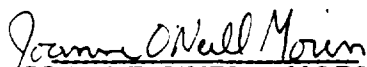
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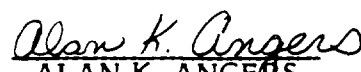
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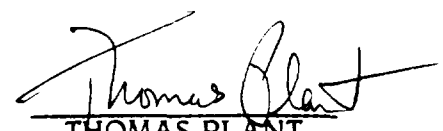
SUBMITTED BY


**JOANNE O'NEILL MORIN
PROJECT MANAGER
CHEMIST**


**ALAN K. ANGERS
ASSISTANT PROJECT MANAGER
GEOLOGIST**

APPROVED BY


**RICHARD G. DINITTO
FIT I MANAGER**


**THOMAS PLANT
QUALITY ASSURANCE**

CONTRIBUTORS

This Remedial Investigation reflects the cumulative efforts of the entire NUS/FIT technical and support staffs. Substantial efforts were made by the technical staff during field tasks that were conducted under sometimes adverse weather conditions. Appreciation is extended to the support staff for their long hours they spent in preparation of all project deliverables. Special mention is given to Michael Rooney for his assistance in development and preparation of graphical presentations. The substantial efforts put forth by Dave Delaney (EPA Region I) during both field activities and report preparation were greatly appreciated by the authors.

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EXECUTIVE SUMMARY

The NUS Corporation Region I Field Investigation Team (NUS/FIT) was directed by the Waste Management Division (Superfund Branch) of the Region I U.S. Environmental Protection Agency (EPA) to design and implement a hydrogeologic Remedial Investigation of the Wells G & H site in Woburn, Massachusetts. The purpose of the Remedial Investigation Part I was to determine the nature and extent of groundwater contamination at the Wells G & H site, and to collect data necessary to support a Feasibility Study. GCA Technology Division, Incorporated (GCA) of Bedford, Massachusetts will address contaminant source characterization and assessment of environmental impact of waste disposal activities in a separate Remedial Investigation report (Wells G & H Remedial Investigation Part II).

This report summarizes site history and environmental investigations conducted at the site by others, describes NUS/FIT Remedial Investigation efforts, and discusses Remedial Investigation findings.

SITE BACKGROUND

The Wells G & H site (hereafter referred to as the site or the Study Area) is located in the City of Woburn approximately ten miles north of Boston, Massachusetts. The site is bordered by State Route 128 (Interstate Route 95) to the north, Interstate 93 to the east, Cedar Street and Salem Street to the south, and Wildwood Avenue to the west. The approximately 450 acre site includes part of the Aberjona River Floodplain and light commercial and industrial parks bordering the river floodplain.

In May, 1979, the Massachusetts Department of Environmental Quality Engineering (DEQE) analyzed water sampled from Wells G & H and detected concentrations ranging from 1 to 400 parts per billion (ppb) of several chlorinated volatile organic

compounds including: trichloroethene, trans-1,2-dichloroethene, 1,1,1-trichloroethane, and tetra-chloroethene. The sampling of Wells G & H was performed in response to the discovery (by DEQE) of drums containing polyurethane and toluene diisocyanate located on a vacant lot on Mishawum Road north of Wells G & H. Wells G & H were subsequently shut down and EPA initiated a series of studies to determine the nature and extent of contamination by hazardous waste in North and East Woburn. Ecology and Environment, the previous EPA/FIT contractor, conducted numerous Site Inspections and hydrogeologic investigations of groundwater and surface water quality of a ten square mile area of East and North Woburn (Section 2.0).

Ecology and Environment's investigations indicated that the major contamination problem within their study area was groundwater contamination by chlorinated volatile organic compounds, primarily trichloroethene, trans-1,2-dichloroethene, 1,1,1-trichloroethane, and tetrachloroethene. Ecology and Environment identified general source areas for some of the contaminants detected at Wells G & H. As a result of Ecology and Environment's investigations and subsequent studies by EPA, three Administrative Orders pursuant to Section 3013 of the Resource Conservation and Recovery Act were issued to W.R. Grace and Co., Inc. (Cryovac Division), UniFirst, Inc., and Beatrice Foods, Inc. in May, 1983. The Administrative Orders requested that these companies determine the nature and extent of groundwater contamination on or emanating from their properties.

In June, 1984, EPA directed NUS/FIT to conduct a Remedial Investigation of the Wells G & H site to determine the nature and extent of groundwater contamination and to gather all necessary data to support the Feasibility Study. The Remedial Investigation Part I objectives were to describe the hydrogeology of the Wells G & H site, to identify contaminant source areas, to provide data sufficient to support the Feasibility Study, and to collect information adequate to support enforcement actions.

Field activities conducted during the NUS/FIT Remedial Investigation included the following:

- Initial groundwater, surface water, and sediment sampling for volatile organic analysis by NUS/FIT.
- Installation of 55 groundwater monitoring wells at 24 locations.
- Collection of surficial soil, overburden and bedrock cores during monitoring well installation.
- In-situ (field) permeability testing and laboratory grain size analysis of soil samples.
- Vertical and horizontal datum control surveying of new and previously existing monitoring wells.
- Three groundwater and surface water sampling rounds for chemical analysis for EPA Hazardous Substance List (HSL) constituents through the EPA contract laboratory program (CLP).
- Measurement of water levels in new and previously existing monitoring wells.
- Performance of a magnetometry survey.

The field investigative phase of the Remedial Investigation was conducted between October, 1984 and June, 1985, and resulted in the following findings:

- The most prevalent and widespread contamination at the site was volatile organic contamination of groundwater. The predominant volatile organic compounds detected were trichloroethene, tetrachloroethene, trans-1,2-dichloroethene, and 1,1,1-trichloroethane.

- Based on an evaluation of the distribution of groundwater contamination, the overburden stratigraphy, groundwater flow directions, and the pathways and mechanisms of contaminant transport, four areas of groundwater contamination were identified: a northeastern plume of volatile organic groundwater contamination consisting primarily of trichloroethene and trans-1,2-dichloroethene, a northern plume of volatile organic contamination consisting primarily of tetrachloroethene, a western area of shallow overburden groundwater contamination consisting primarily of trichloroethene with isolated high concentrations of other chlorinated volatile organic compounds, and a northwestern contaminant area consisting primarily of the volatile organic and extractable organic constituents of gasoline.

- Source areas of contamination were identified as follows: the northeastern plume of groundwater contamination emanates from the W.R. Grace property, the northern plume of groundwater contamination emanates from the UniFirst Corporation property, the western area of groundwater contamination primarily emanates from the Wildwood Conservation Corporation property, and the northwestern area of groundwater contamination likely emanates from a gasoline spill(s) or leaky underground storage tank(s).

1.0 INTRODUCTION

The NUS Corporation Region I Field Investigation Team (NUS/FIT) was directed by the Region I Waste Management Division (Superfund Branch) of the U.S. Environmental Protection Agency (EPA) under Technical Directive Document (TDD) Nos. F1-8311-06, F1-8405-02, and F1-8409-01 to conduct a hydrogeologic Remedial Investigation of the Wells G & H site in Woburn, Massachusetts. This report constitutes Part I of a two part investigation. The second part, a contaminant source characterization and assessment of the environmental impact of waste disposal activities, is also being conducted by GCA. This report presents the description, results, and conclusions of the hydrogeologic Remedial Investigation (Part I). GCA will submit Part II of the Remedial Investigation (source characterization and assessment) as a separate document. The Feasibility Study will include an Endangerment Assessment that will summarize the hazardous compounds of concern, assess the significance of contamination migration routes and exposure pathways, and evaluate endangerment to public health, biota, natural resources, and wetlands.

NUS/FIT was directed to develop a Scope of Work for a Hydrogeologic Field Investigation of the Wells G & H site to identify the source(s) of contamination to Wells G & H and to provide data to support the Feasibility study (TDDs F1-8311-06, F1-8405-02 and F1-8409-01). The Scope of Work for the Remedial Investigation is presented in Appendix A. The Remedial Investigation was divided into two phases. Phase I consisted of initial planning, procurement, and sampling activities; and Phase II included the subsequent site investigation activities. Phase I activities included:

- review of existing data
- planning site access and preparation of a base map
- procurement of subcontractors
- mobilization of equipment
- performance of an initial round of environmental sampling

Phase II activities included:

- installation of groundwater monitoring wells
- in-situ permeability testing and grain size analysis
- ground and surface water sampling for chemical analysis
- vertical and horizontal datum control surveying
- aquifer testing

A chronological summary of NUS/FIT activities is presented in Table 1-1.

The United States Geological Survey (USGS), through a cooperative agreement with EPA, designed an aquifer test and recommended the installation of additional monitoring wells to provide water level measuring points. EPA subcontracted the installation of these monitoring wells to the US Army Corps of Engineers (COE). Geologic data collected by the COE during monitoring well installation is included in Appendix B. An aquifer test report describing the area of influence and zone of contribution to Wells G & H will be released by USGS.

The following is a brief summary of subsequent chapters:

- Chapter 2 presents site history and discusses the scope and findings of investigations conducted by EPA, DEQE, and consultants active in the area.
- Chapter 3 describes the methods used by NUS/FIT to conduct the Remedial Investigation.
- Chapter 4 discusses the geologic and hydrologic setting of the site.
- Chapter 5 presents the analytical results of the Remedial Investigation.
- Chapter 6 is a summary of conclusions regarding the nature and extent of contamination at the site.

TABLE 1-1
CHRONOLOGICAL SUMMARY OF NUS/FIT INVOLVEMENT

29 November 1983	TDD No. F1-8311-06 issued by EPA to prepare a Scope of Work for a Field Investigation
13 January 1984	Draft Scope of Work for a Field Investigation of the Wells G & H Site submitted to EPA.
January February 1984	Meetings were held between NUS/FIT, GCA, EPA, and DEQE to discuss data needs of the Feasibility Study and review comments on the scope of work.
07 May 1984	TDD No. F1-8405-02 issued by EPA to revise Scope of Work and begin Phase I activities.
11 June 1984	Draft Scope of Work for a Remedial Investigation submitted to EPA.
17-26 July 1984	Phase I Sampling conducted. Samples were analyzed by NUS/FIT for volatile organic compounds to prevent delays due to limited Contract Laboratory Program (CLP) regional allocations.
31 October 1985	Installation of 55 groundwater monitoring wells at 24 locations.
02-04 April 1985	Water levels measured in all newly installed wells and accessible existing wells in the study area.
April-Sept. 1985	Collection of water level measurements of selected monitoring wells.
April-June 1985	Groundwater and surface water environmental sampling conducted for CLP analysis.
11&30 November 1985	Ground surveying of monitoring wells conducted.
20 December 1985	Draft Remedial Investigation Report submitted to EPA.
17 October 1986	Final Remedial Investigation Report submitted to EPA.

1.1 Purpose and Objectives of the Remedial Investigation

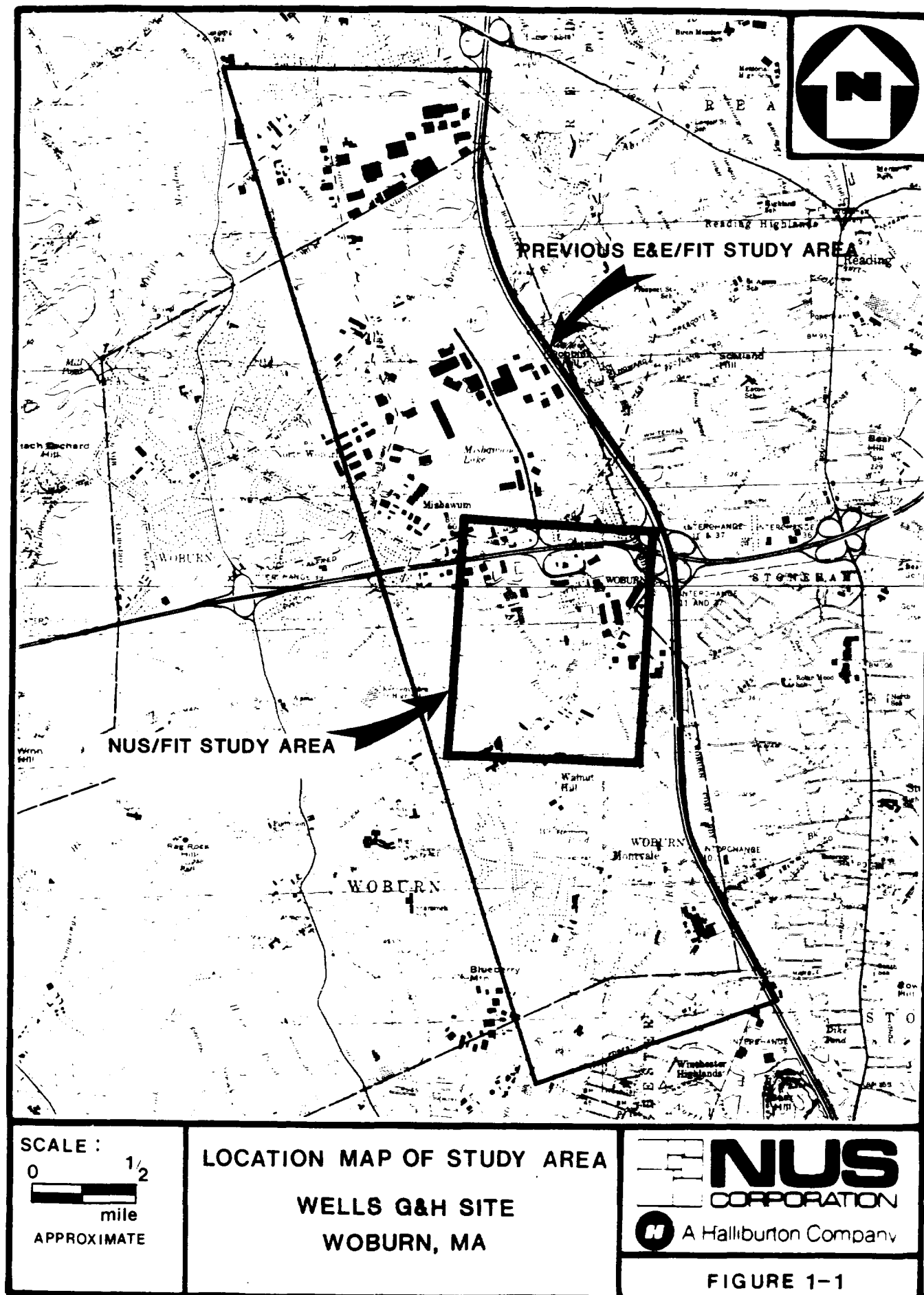
The purpose of the Remedial Investigation Part I is to determine the nature and extent of groundwater contamination at the Wells G & H site and to gather data to support the Feasibility Study. The investigation focused on collecting the data required to determine the need for and extent of remedial action, and for development and evaluation of remedial alternatives during the subsequent Feasibility Study. The data requirements specific to the Feasibility Study were established by GCA following preliminary evaluation of all potentially applicable remediation techniques.

The objectives of the Remedial Investigation were to provide sufficient information and interpretation to accomplish the following:

- Describe the hydrogeology of the Wells G & H aquifer area including surface water and groundwater movement, pathways and mechanisms of contaminant transport, and contaminant source areas.
- Develop a hydrogeologic and chemical database sufficient to support a Feasibility Study to identify and evaluate remedial alternatives for mitigating the effects of groundwater contamination at the Wells G & H aquifer area.
- Investigate suspected contaminant source areas, identify properties that have contributed contamination to the Wells G & H aquifer area, and collect information adequate to support enforcement actions and remediation or source control.

1.2 Site Description

The Wells G & H site is located approximately ten miles north of Boston within the City of Woburn, Massachusetts, at the approximate coordinates of 42° 29' 40" north and 71° 07' 52" west (Figure 1-1). The site is bounded to the north by State Route



BASE MAP IS A PORTION OF THE U.S.G.S. LEXINGTON-BOSTON NORTH, READING & WILMINGTON
QUADRANGLE 7.5 SERIES, 1971-1979.

128 (Interstate Route 95), to the east by Interstate 93, to the south by Cedar Street and Salem Street, and to the west by Wildwood Avenue (Plate 1).

The Wells G & H site will also be referred to in this report as the Wells G & H aquifer area. The Wells G & H aquifer area is also geographically defined as the valley and surrounding uplands associated with the Aberjona River south of Interstate 95 and north of Salem Street. The aquifer area is hydrologically defined as the area (vertically and laterally) that is potentially capable of supplying water to Wells G & H under pumping conditions. The study area encompasses and is somewhat larger than the Wells G & H aquifer area. The northern and southern boundaries of the site are located where background levels of groundwater contamination can be demonstrated.

The study area, approximately 450 acres, encompasses highly developed light commercial and light industrial parks bordering the swampy terrain associated with the Aberjona River floodplain. The Aberjona River flows south through the center of the site and splits into two main channels south of Olympia Avenue. These two main branches converge to form a single channel approximately 1,000 feet downstream from the divergence. Swampy terrain exists between the two channels and also extends at least 400 feet on either side of the river. The Woburn Municipal Wells G & H are located on small man-made knolls of land to the east of the river. Massachusetts Rifle Association property and a residential development near Dewey Avenue are located northeast of the well field, and several residences are located east and south of the well field. Residential development dominates the areas outside of the study area to the east, south, and west. The Industriplex Superfund site is located north and upgradient of Wells G & H. Industriplex consists of a 244-acre industrial park. A Remedial Investigation and Feasibility Study of the Industriplex site has been completed and has been reviewed by EPA. The Wells G & H Remedial Investigation discusses groundwater contamination at Industriplex and its impact on the Wells G & H aquifer area.

Surface elevations rise from 43 feet above mean sea level (MSL) at the Aberjona River to a maximum elevation of 120 feet in the northeast corner of the site. The

elevation of the Aberjona River decreases by approximately five feet from north to south across the site. Surface drainage is affected by a large amount of impervious surface (pavement and parking lots); most of the surface water runoff is directed towards the river via culverts. Two man-made ponds collect runoff in the Wildwood Avenue industrial park. Runoff to these ponds drains via an unnamed stream to the Aberjona River.

2.0 SITE HISTORY AND ADDITIONAL STUDIES CONDUCTED AT THE SITE

Wells G & H were developed by the City of Woburn in 1964 and 1967, respectively, in response to urban growth during the 1960's. The wells, screened in the Aberjona aquifer, were capable of supplying two million gallons of water per day, but were initially intended only for use during times of water shortage or emergencies. Local officials estimate that 27-28% of the community's water supply was provided by Wells G & H. The remainder of the water supply was provided by seven wells located near Horn Pond south of Salem Street. These wells are located in a different aquifer from Wells G & H and are not affected by contamination present in the study area. Local records indicate that the water from Wells G & H exhibited high concentrations of manganese and iron, which resulted in unpleasant taste and odor. Prompted by citizens' complaints concerning water quality, and in order to meet anticipated increased demand for water, the City of Woburn examined the feasibility of treating the water in 1974 (NUS, 1985). However, treatment was not implemented.

On May 4, 1979, 184 55-gallon drums containing polyurethane and toluene diisocyanate were found on a vacant lot located on Mishawum Road on property owned by the Massachusetts Bay Transit Authority (MBTA). The drums were removed by unknown parties during negotiations with the Massachusetts Department of Environmental Quality Engineering (DEQE) over removal of these drums. This incident prompted DEQE to sample the nearest downgradient water supply, Woburn's municipal water supply from Wells G & H, as a precautionary measure.

Several chlorinated volatile organic compounds including 1,1,1-trichloroethane (1,1,1-TCA), trans-1,2-dichloroethene (trans-1,2-DCE), tetrachloroethene (TETRA), trichloroethene (TCE), chloroform, and trichlorotrifluoroethane were detected by DEQE in water from Wells G & H at concentrations ranging from 1 to 400 part per billion (ppb). (Note that the endings "ylene" and "ene" are equivalent such that trichloroethylene and trichloroethene are the same compound. Similarly,

tetrachloroethylene, also commonly called perchloroethylene or perc and tetrachloroethene are the same compound). Wells G & H were subsequently shut down on May 21, 1979, forcing the City of Woburn to use Metropolitan District Commission (MDC) water to supplement its public water supply. Currently, the MDC supplies approximately one third of the city's water needs (approximately two million gallons per day). The remainder, approximately four million gallons per day, is supplied by the Horn Pond well field (NUS, 1985).

During the mid to late 1970's, the local community became concerned over the incidence of childhood leukemia, particularly in the Pine Street area of east Woburn. After DEQE detected volatile organic contamination in Wells G & H in 1979, some members of the local community suspected that the incidence of leukemia was linked to the possible exposure to volatile organic chemicals through the Wells G & H water supply. The Massachusetts Department of Public Health (MDPH) began investigating the problem in December, 1979. A higher than expected rate of childhood leukemia was confirmed by the MDPH in April, 1980.

Upgradient of Wells G & H, another area of waste disposal (the Industriplex site) came to the attention of local, state, and federal officials in the 1970's, when the owner began developing a portion of the site (Ecology and Environment, 1982b). Filling and excavating activities created noxious odors which prompted citizen complaints.

The Industriplex site, located north of Interstate 95 (state route 128), has a long history of chemical manufacturing activity. Robert B. Eaton's Chemical Works produced chemicals for the textile, leather, and paper industries of New England since beginning operation in 1853. Merrimac Chemical Company purchased the property in 1863 and produced lead-arsenic pesticides, acids, trinitrotoluene (TNT), and various inorganic compounds. By 1929, Merrimac Chemical was one of the largest chemical manufacturers in the country (Ecology and Environment, 1982b). New England Chemical began animal hide glue manufacturing on the site in 1934. The firm was purchased by Consolidated Chemical Company in 1936 and was subsequently purchased by Stauffer Chemical Company in the late 1950's. By

December 31, 1968, the bulk of the property was sold to the Mark Phillips Trust which subsequently began development of an industrial park (Industriplex) on the site (Roux, 1983b).

Soils contaminated with heavy metals and arsenic exist on the Industriplex site. Volatile organic contamination consisting of benzene, methylene chloride, toluene, trichloroethene (TCE), carbon tetrachloride, 1,2-dichloroethane, and 1,1,1-trichloroethane (1,1,1-TCA) has been found in the groundwater beneath the site (Roux, 1983a). A Remedial Investigation/Feasibility Study (RI/FS) of the Industriplex site has been completed by Stauffer Chemical Company under a consent agreement with EPA and is currently undergoing EPA review.

As a result of the detected contamination at Wells G & H and disposal problems discovered at the Industriplex site, the previous FIT contractor, Ecology and Environment, Inc. (E & E), was directed by EPA to conduct a hydrogeologic investigation and groundwater quality evaluation of a ten square mile portion of East and North Woburn (Ecology & Environment, Inc, 1982b). The purpose of this investigation was to determine the extent and degree of contamination, and to identify the sources of contamination. Based on the direction of groundwater flow, areal extent of groundwater contamination, and Site Inspections of seventeen active and inactive facilities within the ten square mile area, E & E identified the general source areas for TCE, trans-1,2-DCE, 1,1,1-TCA, and TETRA detected at Wells G & H to be within a one square mile area surrounding the wells. The contamination at the Industriplex site was not linked with that found at Wells G & H. EPA developed a Hazard Ranking System (HRS) score for the Wells G & H site utilizing E & E's preliminary investigations and the analytical information provided by DEQE. The site was listed on the National Priorities List (NPL) on December 21, 1982.

In May, 1983, as a result of E & E's investigations, three administrative orders pursuant to Section 3013 of the Resource Conservation and Recovery Act (RCRA) were issued to W.R. Grace and Co., Inc. (Cryovac Division), UniFirst Corporation (formerly Interstate Uniform Services Corporation), and Beatrice Foods, Inc..

These orders required submittal of proposals by each company for the sampling, analysis, monitoring, and reporting that would address the problem of possible groundwater contamination on or emanating from their properties. Groundwater monitoring programs were subsequently initiated by the three companies, and included:

- Investigations (geophysical surveys, test pit excavation, monitoring well installation, groundwater sampling) conducted at the W.R. Grace site by GeoEnvironmental Consultants.
- Investigations (monitoring well installations, groundwater sampling) conducted at the UniFirst Corporation site by Environmental Research and Technology, Inc. (ERT).
- Investigations (review of historical aerial photographs, soil sampling, monitoring well installations, groundwater sampling, performance of an aquifer test) conducted at the Wildwood Conservation Corporation site (Beatrice Foods site) by Woodward-Clyde Consultants.

7 In 1982, EPA directed Camp, Dresser, & McKee (CDM) to prepare a Remedial Action Master Plan (RAMP) for the Wells G & H site. The RAMP's purpose was "to identify the type, scope and sequence of activities to identify and implement a remedial action(s) to mitigate the effects of the contaminants in East Woburn" (Camp, Dresser, & McKee, 1983).

In May, 1982, a number of citizens whose children had developed leukemia filed a civil lawsuit against two companies (W.R. Grace/Cryovac Division and Beatrice Foods) suspected of contributing contamination to Wells G & H. In April, 1985, the same citizen's group brought civil lawsuits against a third company: UniFirst Corporation. The civil lawsuits brought against the first two companies in 1982 was recently settled out of court following part of what was planned as a three part trial. The civil lawsuit filed against UniFirst Corporation was settled out of court in October, 1985.

Since the initiation of the NUS/FIT Remedial Investigation in 1984, additional work has been conducted in the study area. An Environmental Site Assessment of 60 Olympia Avenue was conducted by Goldberg-Zoino and Associates (GZA), Inc. (Newton Falls, Massachusetts) for Juniper Development Group (Winchester, Massachusetts) in February, 1985. EPA conducted additional soil sampling on Juniper Development Group property in September, 1985. In the fall of 1985, EPA, through a cooperative agreement with the USGS, also designed and implemented an aquifer test of Wells G & H which included installation of groundwater monitoring wells.

A description of other studies conducted in the Remedial Investigation study area follows and is also summarized in Table 2-1. Locations of other studies are depicted in Figure 2-1. The studies conducted in North Woburn will be evaluated as they pertain to the Wells G & H aquifer area which is located downgradient of the Industriplex site.

Data collected by parties other than NUS/FIT underwent a limited quality control review (data validation) by either GCA of Bedford, Massachusetts (an EPA contractor) or by the Environmental Services Division of EPA. As the analyses were not conducted according to all EPA Contract Laboratory Program (CLP) requirements, a complete validation was not possible. In addition, this report does not address whether proper sampling plans, procedures or quality control were employed in collection of these samples, nor does it address the integrity of the sampling points themselves.

2.1 Investigations Conducted in North Woburn by Roux Associates for Stauffer Chemical Company

As previously discussed, North Woburn has a long history of chemical manufacturing and hazardous waste disposal. There are various waste disposal problems in North Woburn including: chromium and arsenic pits, decaying animal hide piles, heavy metal contamination, and groundwater contamination by volatile organic compounds. In general, metals tend to adsorb onto soil organic matter and

TABLE 2-1

SUMMARY OF PREVIOUS STUDIES

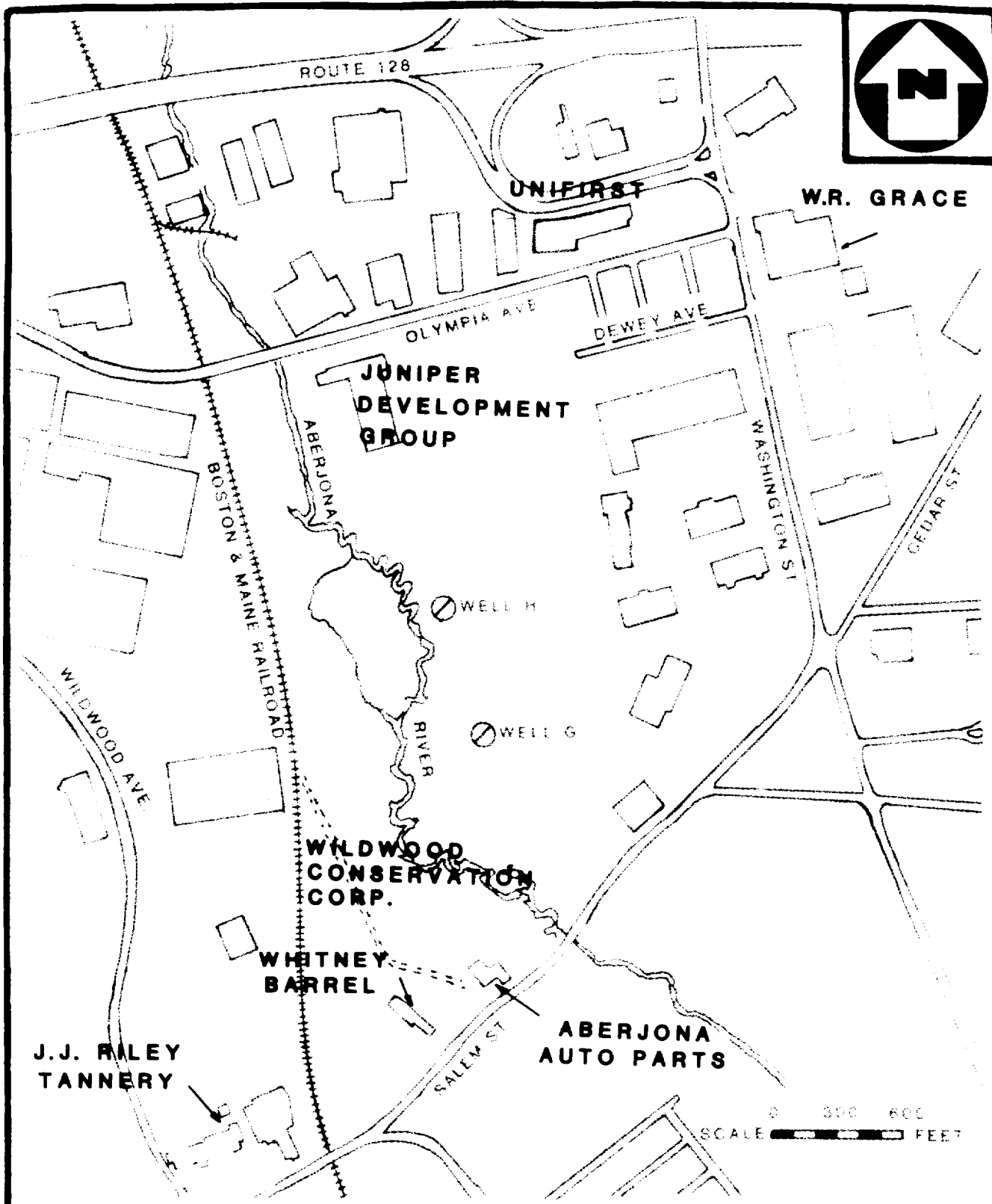
Date of Study	Conducted by	Objectives	Results/Conclusions
1980	Ecology & Environment (for EPA)	To conduct a Site Inspection (SI) of Aberjona Auto Parts.	Aberjona Auto Parts purchases wrecked autos, used autos and auto parts for reconditioning and resale. The operation uses a degreasing chemical and stores waste oil and transmission fluid in an underground tank.
1980	Ecology & Environment (for EPA)	To conduct a Site Inspection of John J. Riley Company	The John J. Riley Company consists of a tannery and an additional unused parcel of land. The unused property contained miscellaneous debris, empty oil tanks and rusted 55 gallon drums.
1980	Ecology & Environment (for EPA)	To conduct a Site Inspection of the Whitney Barrel Company	The Whitney Barrel Company reconditions drums, boiler tanks, and machinery, mainly from the food industry. The SI noted poor housekeeping with numerous containers stacked three to four containers high. Empty drums with labels for malathion, acrylic lacquer thinner, and methylene chloride were documented. A full drum of trichloroisocyanuric acid was found on site.
1981-1982	Ecology & Environment (for EPA)	Define extent and degree of contamination in North and East Woburn.	Major groundwater problem within study area was widespread. Contamination by chlorinated volatile organic compounds.
1983	Camp, Dresser & Mckee (for EPA)	To develop a Remedial Action Master Plan for the Well G&H site.	The RAMP reviewed potential application of various pump and treat technologies to Wells G&H, and proposed a Remedial Investigation.

**TABLE 2-1
SUMMARY OF PREVIOUS STUDIES
PAGE TWO**

Date of Study	Conducted by	Objectives	Results/Conclusions
1983-1985	GeoEnvironmental Consultants (for W.R. Grace/Cryovac Division)	Evaluate extent and degree of possible contamination on or emanating from W.R. Grace/Cryovac Division's property.	Onsite volatile organic groundwater contamination was detected. Buried drums were excavated and sampled. The contents of the drums contained volatile organic compounds.
1984-1985	Woodward-Clyde Consultants (for Beatrice Foods)	Evaluate extent and degree of possible groundwater contamination on or emanating from the Beatrice Foods site.	Onsite shallow overburden volatile organic groundwater contamination was detected. Soil contamination by volatile organic compounds was also detected. Aerial photography documented use of the property for storage of drums, tanks and miscellaneous debris.
1984	Environmental Research & Technology (for UniFirst)	To determine if a source of tetrachloroethene groundwater contamination existed upgradient of the UniFirst facility.	No upgradient source of tetrachloroethene groundwater contamination was detected.
1982-1985	Roux Associates (for Stauffer Chemical Company)	To determine extent and degree of contamination at the Industriplex site, North Woburn.	Volatile organic contamination of groundwater was detected. Surficial deposits of metals were also detected.
1985	Goldberg-Zoino and Associates (for Juniper Development Group)	Site assessment of 60 Olympia Avenue pursuant to Massachusetts General Laws 21E	Volatile organic contamination of groundwater by suspected gasoline constituents. High concentrations of a pesticide and PCBs were detected in soils adjacent to some abandoned rusted drums.

TABLE 2-1
SUMMARY OF PREVIOUS STUDIES
PAGE THREE

Date of Study	Conducted by	Objectives	Results/Conclusions
1985	EPA	Sampling of contents and soils surrounding abandoned drums on Juniper Development Group property.	Soil contamination by volatile organic compounds, pesticides, and PCBs.



**SITE MAP
WELLS G AND H
WOBBURN, MA**

NUS
CORPORATION
A Halliburton Company

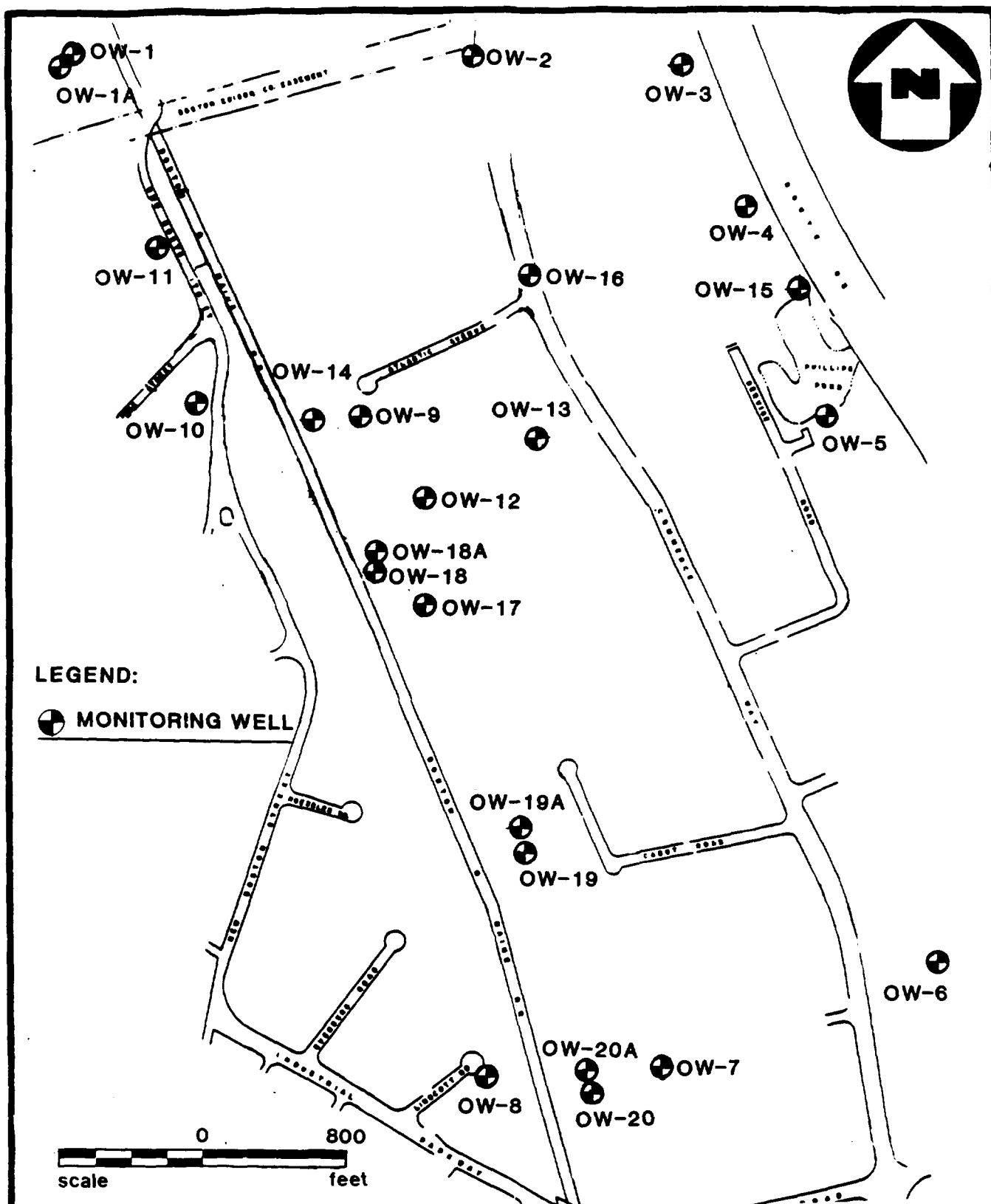
-FIGURE 2-1

do not tend to migrate to groundwater. This has been demonstrated in North Woburn, where the waste disposal associated with metals is localized and has not migrated beyond the disposal areas. The metal waste problems are not expected to affect the Wells G & H site. However, volatile organic compounds in groundwater would tend to migrate downgradient towards Wells G & H (if no remedial action is taken) and could affect the site.

Roux Associates have conducted a hydrogeologic study of the Industriplex site in North Woburn for the Stauffer Chemical Company. Their work included (but was not limited to) the following: installation of twenty-four groundwater monitoring wells, an electrical conductivity survey, a soil boring program, and extensive sampling and chemical analysis (Roux, 1983a and 1984). The Industriplex site and the location of the Roux Associates' monitoring wells are depicted in Figure 2-2.

Roux Associates reported in 1982 that groundwater samples collected from five of the original fifteen monitoring wells contained concentrations of metals exceeding National Interim Primary Drinking Water Regulations Maximum Contaminant Levels (MCLS). In 1983, eight of the now twenty-four monitoring wells contained metals (arsenic, lead, zinc) in concentrations exceeding drinking water standards. Roux Associates concluded that the contamination was sporadic, and therefore did not indicate a significant plume of metal contamination affecting groundwater.

Contamination has been found in groundwater at the Industriplex site. Of particular significance to the Wells G & H Remedial Investigation is the occurrence of the volatile organic compounds such as benzene, toluene, phenol, acetone, and methyl ethyl ketone (MEK). Benzene was found in wells OW-12 and OW-17 (see Figure 2-2 for locations) at 491 and 747 ppb; toluene in well OW-12 (177 ppb); phenol in wells OW-12 and OW-17 (236-453 ppb); and acetone and MEK in well OW-16 at 2,110 and 276 ppb respectively. No volatile organic compounds were detected at wells OW-19, OW-19A, OW-20, and OW-20A which are installed downgradient from the contaminant plume. Roux Associates concluded that the volatile organic plume was limited to an area somewhere between OW-17 and OW-19, but expected it to move downgradient rapidly and reach wells OW-19 and OW-19A in 1985 or shortly thereafter.



INDUSTRIPLEX STUDY AREA IN NORTH WOBURN

FIGURE FROM PHASE II INVESTIGATION REPORT MARCH 1984.
PREPARED BY ROUX ASSOCIATES FOR
STAUFFER CHEMICAL COMPANY



FIGURE 2-2

2.2 Site Inspections and Field Investigations Conducted by Ecology and Environment

Numerous Site Inspections (SIs) were conducted by E & E within and near the study area. The SIs conducted within the study area included Whitney Barrel, Aberjona Auto Parts, and John J. Riley Tannery, and will be discussed in this section.

Brief summaries for each facility are provided as follows:

- The Whitney Barrel Company began operations in 1949 and is currently involved in reconditioning drums, boilers, tanks, and machinery, primarily from the food industry.

All containers (from the food industry) were cleaned onsite, originally with a caustic soda and trisodium phosphate (TSP) solution and later with TSP only. The rinse water was discharged to the MDC sewer under a RCRA permit. Non-food industry containers were cleaned offsite. Whitney Barrel Co. also dealt in scrap metal and in reducing large containers or machinery into sections and selling them (Ecology and Environment, 1980c).

The E & E Site Inspection conducted in 1980 at the Whitney Barrel Co. noted poor housekeeping with numerous containers onsite stacked three to four containers high, and numerous pieces of scrap machinery and equipment in various stages of deterioration. Empty drums with labels for malathion, acrylic lacquer thinner, and methylene chloride were documented. Mr. John Whitney, the site owner, claimed that these drums were cleaned prior to receipt. However, a full drum of trichloroisocyanuric acid was found onsite. A chemical odor was also noted during the inspection, although no readings above background levels were noted on an Organic Vapor Analyzer (OVA) (Ecology and Environment, 1980c).

- Aberjona Auto Parts purchases wrecked autos, used autos, and auto parts for reconditioning and eventual resale. The facility has been in operation for approximately 30 years. The operation uses a degreasing chemical (trade name ZEP) which is stored on site in drums. Auto parts are sprayed with ZEP and rinsed with water. The rinse water is collected in a grease pit which empties to the MDC sewer. Spent solution in the grease pit is sometimes picked up by Murphy Waste Oil for reprocessing. The site was formerly a gas station with two underground gasoline storage tanks located on the south side of the property. These were drained when gasoline sales were terminated. An additional 500-gallon underground tank located at the southeast corner of the garage stores waste oil and transmission fluid. The contents of the tank were periodically emptied by Murphy Waste Oil for processing and eventual resale as fuel oil (Ecology and Environment, 1980a).
- The John J. Riley Company consisted of a tannery and an additional undeveloped parcel of land. The tannery is located at 228 Salem Street and consists of two buildings (a process plant and offices), two defunct chromium lagoons, and piles of unprocessed hides located behind the process building. The chromium lagoons were located beyond the hide piles to the north of the facility and were last used in 1970 according to John J. Riley. The John J. Riley Company began operations in 1909 and was sold to Beatrice Foods, Inc. in 1978 when the John J. Riley Company became a division of Beatrice Foods. In 1983, John J. Riley again assumed ownership of the firm. In 1985, the tannery was sold to its employees which continued to operate as the John J. Riley Company. The undeveloped parcel of land was established as the Wildwood Conservation Corporation by John J. Riley at approximately the same time. Both the tannery and undeveloped parcel of land were the subject of the E & E Site Inspection (Ecology and Environment, 1980b). The undeveloped parcel of land came under further study by EPA during the time it was owned by Beatrice Foods, Inc.. The unused parcel of land will hereafter be referred to as the Wildwood Conservation Corporation site (Plate 1).

The E & E Site Inspection Report, which focused primarily on the factory and land immediately surrounding the factory, noted the following:

- Chromium and benzidine dye wastes were disposed of in the lagoons, but this practice was halted and no evidence of recent use of the lagoons was found. The lagoons were located near the factory building.
- Sludge material from process sedimentation tanks was buried next to the lagoons.
- Except for the location of the second production well (S46), John J. Riley claimed the property located northeast of his facility was not utilized. However, according to an investigation by the DEQE, referenced in the Site Inspection Report, the undeveloped property contained miscellaneous debris, empty oil tanks, and several piles of new and rusted 55-gallon drums.
- The E & E Site Inspection also noted drums and debris on the unused property in addition to numerous pesticide container caps.
- In 1970, 200 to 500 five-gallon drums of arsenic trioxide were found just north of the undeveloped parcel of land. The drums were subsequently removed shortly after they were found. Initially, E & E thought this property was owned by John J. Riley but upon further investigation found it was owned by Hemingway Trucking Company (Ecology and Environment, 1980b).
- E & E was also directed by EPA to conduct a hydrogeologic field investigation and groundwater quality evaluation of a ten square mile portion of East and North Woburn (Figure 1-1). The investigation included a seismic refraction survey (a geophysical method used to determine depth to bedrock), installation of groundwater monitoring wells, development of a bedrock surface contour map and a water table contour

map, development of geologic cross-sections, and groundwater sampling and analysis. The objective of the field investigation was to define the extent and degree of groundwater contamination in north and east Woburn. The results of the study were presented in a number of interim and draft reports. This discussion will focus on the final reports entitled: "Evaluation of the Hydrogeology and Groundwater Quality of East and North Woburn, Massachusetts, 25 June 1982, TDD No. F1-8109-02" and "Chlorinated Solvent Contamination of the Groundwater, East Central Woburn, Massachusetts, 8 March 1982, TDD No. F1-8203-01" (Ecology and Environment, 1982a and 1982b). The following discussion will emphasize those results pertinent to the NUS/FIT Remedial Investigation study area.

In 1980, E & E inventoried forty municipal, industrial and private wells in the East Central Woburn study area. E & E augmented that number with the installation of twenty-two monitoring wells in 1981. These sixty two wells were designated "S" wells. Wells installed by E & E were numbered S1 to S22. The municipal, industrial and private wells were assigned numbers S23 through S62, respectively. This numbering system has been retained in the NUS/FIT Remedial Investigation. Note that dashes have been incorporated into these and other well numbers (e.g. S-1) when presenting analytical data. E & E obtained groundwater samples from all the newly installed wells (S1 through S22). Groundwater samples were also drawn from the pre-existing wells wherever feasible.

E & E's work revealed that the major groundwater problem within the study area was contamination by chlorinated volatile organic compounds. The volatile compounds found in highest concentration were TCE; trans-1,2-DCE; 1,1,1-TCA; and TETRA. The highest concentrations (>300 ppb) of TCE and trans-1,2-DCE were detected at monitoring well S21 (West Cummings Park) and well S46 (John J. Riley's production well no. 2) located on the undeveloped parcel of land later to be known as the Wildwood Conservation Corporation site (Beatrice Foods site) (Plate 2). Well S46 also contained high levels of 1,1,1-TCA (100 to 200 ppb). High levels of TETRA (>200 ppb) were detected at Well S6, north of Wells G & H.

E & E identified potential source areas for the release of these compounds based on information concerning historic use of the compounds by industries in the area upgradient of the contaminated groundwater monitoring wells. E & E suggested that the source of TCE and trans-1,2-DCE contamination at well S21 (located alongside the 200 West Cummings Park building) was to the north or northeast. Similarly, E & E found that hydrogeologic data indicated the source of TETRA contamination at well S6, located approximately 1,700 feet north of Well H, to be to the north or northeast. Lack of sufficient hydrologic data precluded any suggestion of source direction at John J. Riley Production Well No. 2 (S46) which is located approximately 1,000 feet southwest of Well G.

2.3 Draft Remedial Action Master Plan for East Woburn Prepared by Camp, Dresser, & McKee (CDM)

The Draft Remedial Action Master Plan (RAMP) was prepared by Camp, Dresser, & McKee (CDM) under contract to the EPA. Its purpose was "to identify the type, scope and sequence of activities to identify and implement a remedial action(s) to mitigate the effects of the contaminants in East Woburn" (Camp, Dresser & McKee, 1983). This provided a draft work statement for the initiation of work and was developed from existing information including: Industriplex studies, a hydrologic study of the Mystic River watershed which includes the Aberjona River, an urban runoff program case study in the Upper Mystic Lake watershed prepared for DEQE, and E & E's hydrogeologic study of the area.

The RAMP identified volatile organic contamination of groundwater to be the primary problem in the area now delineated as the NUS/FIT study area. CDM's RAMP suggested that the Aberjona River may contribute to the contamination found in Wells G & H. The RAMP also suggested that the sewer lines could represent an additional source of contamination. However, an Infiltration/Inflow Study conducted by Whitman and Howard, Inc. in November, 1983 demonstrated that a strong gradient exists into the sewer line except at times of peak rainfall when overflowing can occur at various manholes (Whitman and Howard, 1983). This finding suggests that the sewer line would not be a likely source of groundwater contamination.

The RAMP reviewed the potential application of various pump and treat technologies to the site and proposed that a Remedial Investigation and a Community Relations Plan be prepared.

2.4 Investigations Conducted at W.R. Grace

W.R. Grace's (Cryovac Division) facility, located in the northeastern portion of the study area (Figure 2-1), is a manufacturer of food wrapping equipment. Solvents such as trichloroethene (TCE) are used at the facility as degreasing agents.

In response to an EPA Administrative Order, GeoEnvironmental Consultants (GeoEnvironmental) under contract to W.R. Grace's attorneys submitted a proposal to EPA and DEQE consisting of three phases: Phase I - geophysical surveys; Phase II - installation of groundwater monitoring wells and groundwater sampling; and Phase III - controlled excavation, sampling and removal of material from a resulting pit area east of the Cryovac facility where disposal of paint sludges occurred (GeoEnvironmental, 1983).

Geophysical work conducted in Phase I consisted of magnetometry and resistivity surveys conducted by International Exploration, Inc. in April, 1983. A magnetometry survey was conducted to locate areas of stronger magnetic readings (anomalies) than the general background readings. These stronger readings can be indicative of buried ferrous metals (i.e., drums). Some such anomalies were detected on the facility property. One area in particular showed strong anomalous readings. This data was used to determine the area for the subsequent excavation.

In June, 1983, six drums were unearthed in the area of these anomalous magnetic readings; two contained a small amount of liquid, two contained dried paint residue, and two were empty. Aqueous samples were collected by GeoEnvironmental from two of the drums, and soil and water samples were collected from the bottom of the excavation pit. Split samples were collected by

NUS/FIT. Table 2-2 summarizes analytical results for samples collected by GeoEnvironmental and split samples collected by NUS/FIT. Elevated levels of ethylbenzene (849 ppb), methylene chloride (4,510 ppb), toluene (25,900 ppb), trans-1,2-DCE (9,830 ppb), TCE (105,00 ppb), and vinyl chloride (1,080 ppb) were detected by GeoEnvironmental in one of the aqueous samples from an excavated drum. Volatile organic and extractable organic compounds were detected in the soil samples collected from the excavation area.

A resistivity profile conducted at the W.R. Grace facility property indicated depths to bedrock of 10 to 62 feet below ground surface. In the resistivity method, an electric current is introduced to the ground. Electrical properties inherent to the consolidated and unconsolidated deposits result in changes in electrical resistivity. The depth at which these changes occur are inferred to be the bedrock/overburden interface. During Phase II, the depth to bedrock estimates were significantly revised after evaluation of borehole data collected during the installation of fourteen groundwater monitoring wells by GeoEnvironmental at seven locations in June, 1983.

Fourteen groundwater monitoring wells were installed by GeoEnvironmental at seven locations in June, 1983. Each location typically consisted of one well screened in overburden (two at location No. 2) and an adjacent well screened in the first twenty feet of bedrock. Groundwater monitoring wells installed by GeoEnvironmental for W.R. Grace are denoted in this report with either a GW (onsite wells) or GO (offsite wells). W.R. Grace onsite well locations are depicted on Figure 2-3. A shallow six inch diameter monitoring/recovery well was installed at location No. 6 in the pit area. The logs for these wells are presented in Appendix B.

Twelve additional groundwater monitoring wells were installed by GeoEnvironmental in September and October, 1984 onsite and offsite. Some of these wells were installed at new locations onsite and others were additional bedrock wells installed approximately 90 feet into rock at previous well locations. The offsite well GO1 cluster consists of an overburden, shallow bedrock (twenty

**TABLE 2-2
ANALYTICAL RESULTS
GEOENVIRONMENTAL
VERSUS NUS/FIT SPLIT SAMPLES
COLLECTED AT W.R. GRACE
JUNE 1983**

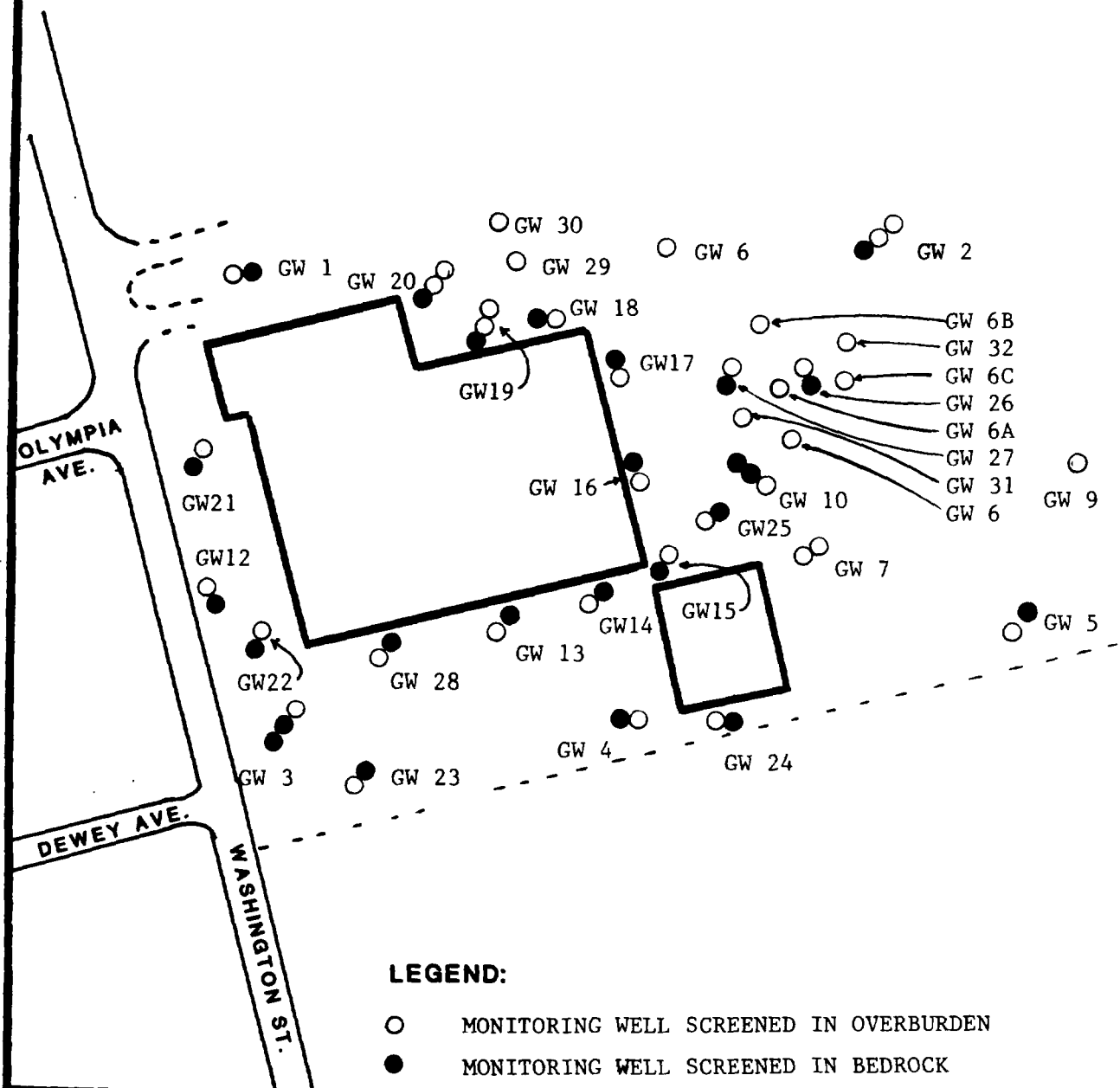
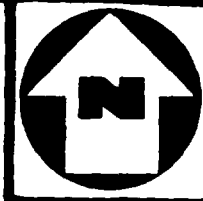
<u>Volatile Compounds</u>	<u>Trench Water (ppb)</u>		<u>Trench Soil (ppb)</u>		<u>Drum #1 (ppb)</u>		<u>Drum #6 (ppb)</u>	
	<u>GEO</u>	<u>NUS</u>	<u>GEO</u>	<u>NUS</u>	<u>GEO</u>	<u>NUS</u>	<u>GEO</u>	<u>NUS</u>
1,1,1-Trichloroethane	-	-	BDL	-	-	-	-	-
1,1-Dichloroethene	-	-	-	-	-	-	BDL	-
Methyl chloride	-	-	-	-	-	-	BDL	-
Tetrachloroethene	-	-	-	-	-	-	BDL	-
Ethylbenzene	81J	36J	-	-	849J	3500J	293J	1030J
Methylene chloride	11J	224J	1960J	28	4510J	4287J	123J	173J
Toluene	-	-	-	10	25900J	22200J	127J	38764J
<u>Trans-1,2-</u> dichloroethene	BDL	-	-	-	9830J	8230J	360J	272J
Trichloroethene	BDL	-	-	-	105000J	170200J	126J	152J
Trichlorofluoro- methane	24J	-	BDL	-	-	-	BDL	-
Vinyl Chloride	BDL	-	-	-	1080J	859J	BDL	-
Chloroform	-	-	-	BDL	-	48J	-	-
Acetone	NA	-	NA	-	NA	83197J	NA	1399J
2-Hexanone	NA	26	NA	-	NA	352200J	NA	152
4-ethyl-2 pentanone	NA	22	NA	-	NA	260400J	NA	1070J
O-xylene	NA	148	NA	-	NA	6790J	NA	3460J
2-butanone	NA	-	NA	-	NA	5820J	NA	-
Carbon disulfide	NA	-	NA	-	NA	289J	NA	-
Styrene	NA	-	NA	-	NA	-	NA	134J
<u>Acid Compounds</u>								
Benzoic acid	NA	-	NA	-	NA	1000J	NA	BDL
2,4-Dimethylphenol	*	-	*	-	*	-	*	27J
Phenol	*	-	*	-	*	-	*	BDL
2-Methylphenol	NA	-	NA	-	NA	-	NA	56J
4-Methylphenol	NA	-	NA	-	NA	-	NA	26J
<u>Base/Neutral Compounds</u>								
Isophorone	*	-	*	-	-	NA	*	-
Naphthalene	*	100J	*	-	NA	170J	*	63J
2-Methylnaphthalene	NA	142J	NA	-	NA	-	NA	-
di-n-butyl phthalate	*	581J	*	224	*	498J	*	-
Bis(2-ethylhexyl)phthalate	*	-	*	-	*	-	*	BDL
Benzyl alcohol	NA	-	NA	-	NA	200J	NA	-
Diethyl phthalate	*	-	*	-	*	-	*	-
<u>Pesticide Compounds</u>	*	-	*	-	*	-	*	-

TABLE 2-2
ANALYTICAL RESULTS
GEOENVIRONMENTAL
VERSUS NUS/FIT SPLIT SAMPLES
COLLECTED AT W.R. GRACE
PAGE TWO

<u>Metals, Cyanide, Phenols</u>	<u>Trench Water</u> (ppb)		<u>Trench Soil</u> (ppb)		<u>Drum #1</u> (ppb)		<u>Drum #6</u> (ppb)	
	<u>GEO</u>	<u>NUS</u>	<u>GEO</u>	<u>NUS</u>	<u>GEO</u>	<u>NUS</u>	<u>GEO</u>	<u>NUS</u>
Arsenic	*	10	*	15	NA	16	NA	16
Chromium	*	-	*	10	NA	-	NA	-
Copper	*	-	*	20	NA	-	NA	-
Nickel	*	-	*	11	NA	-	NA	130
Zinc	*	57	*	64	NA	12900	NA	369000
Aluminum	NA	5940	NA	4980	NA	11700	NA	11400
Barium	NA	-	NA	23	NA	120	NA	230
Beryllium	*	-	*	0.3	*	-	*	6
Cobalt	NA	-	NA	4.7	NA	160	NA	360
Iron	NA	7570	NA	9290	NA	21700	NA	23000
Manganese	NA	530	NA	110	NA	430	NA	4170
Boron	NA	-	NA	-	NA	-	NA	-
Vanadium	NA	-	NA	17	NA	-	NA	-
Silver	*	-	*	-	*	-	*	-
Antimony	*	-	*	-	*	-	*	-
Selenium	*	-	*	-	*	-	*	-
Thallium	*	-	*	-	*	-	*	-
Mercury	*	0.2	*	-	*	-	*	1.5
Tin	NA	-	NA	-	NA	52	NA	-
Cadmium	*	-	*	-	*	1.2	*	14
Lead	*	9	*	4.3	*	180	*	710
Cyanide, Total	*	NA	*	NA	NA	NA	NA	NA
Phenols, Total	*	NA	*	NA	NA	NA	NA	NA

GEO - Data from GeoEnvironmental's Interim Report, August 1983.
 - - Not detected
 BDL - Below detection limit (trace amounts)
 NA - Not analyzed for
 J - Quantitation is approximate due to quality control review (data validation)
 * - Value is rejected due to quality control review

Note: NUS/FIT samples were analyzed for all compounds on the Hazardous Substance List (see Appendix D for a complete list of compounds). Those compounds not listed were not detected.



LEGEND:

- MONITORING WELL SCREENED IN OVERBURDEN
- MONITORING WELL SCREENED IN BEDROCK

**WELL LOCATIONS
W.R. GRACE SITE
WOBURN, MA**



FIGURE 2-3

feet into rock), and deeper bedrock well (50 feet into rock). In the fall of 1985, 37 additional wells were installed at 20 new locations on the property. Additional test pit excavation was conducted which will be discussed in Part II of the Remedial Investigation (source area characterization). Well logs for W.R. Grace wells are presented in Appendix B.

Numerous rounds of groundwater sampling for volatile organic contaminants were conducted by GeoEnvironmental between June, 1983 and December, 1985. The results are presented in Appendix C (Tables 1 and 2).

Based on GeoEnvironmental's analytical results, little or no volatile organic contamination was detected at well locations GW1, GW2, GW5 and GW9. (Note that well numbers are denoted as GW-1, GW-2, etc. in presentation of analytical data). Samples collected from the remaining locations contained various levels of volatile organic contaminants: chloroform, methylene chloride, TETRA, trans-1,2-DCE, TCE, trichlorofluoromethane and vinyl chloride. These data will be further discussed in Chapter 5.0.

2.5 Investigations Conducted at Wildwood Conservation Corporation

Woodward-Clyde Consultants (WCC) was retained by the attorneys for Beatrice Foods, Inc. (Lowenstein, Sandler, Brochin, Kohl, Fisher, Boylan & Meanor) to conduct a hydrogeologic investigation of the Wildwood Conservation Corporation in response to an EPA administrative order pursuant to RCRA Section 3013. The property is located east of the John J. Riley Tannery operations on an undeveloped triangular piece of land encompassing approximately sixteen acres. Beatrice Foods, Inc. owned the property for only a brief period after purchasing it from John J. Riley in 1978. The land was subsequently sold back to John J. Riley and has recently been established as the Wildwood Conservation Corporation. The John J. Riley production well No. 1, an overburden well screened in the Aberjona aquifer, is located west of the Boston & Maine railroad tracks on the tannery property (Figure 2-1). During the E & E Field Investigation, TCE; trans-1,2-DCE; 1,1,1-TCA; and TETRA were detected in Well No. S46 (John J. Riley production well

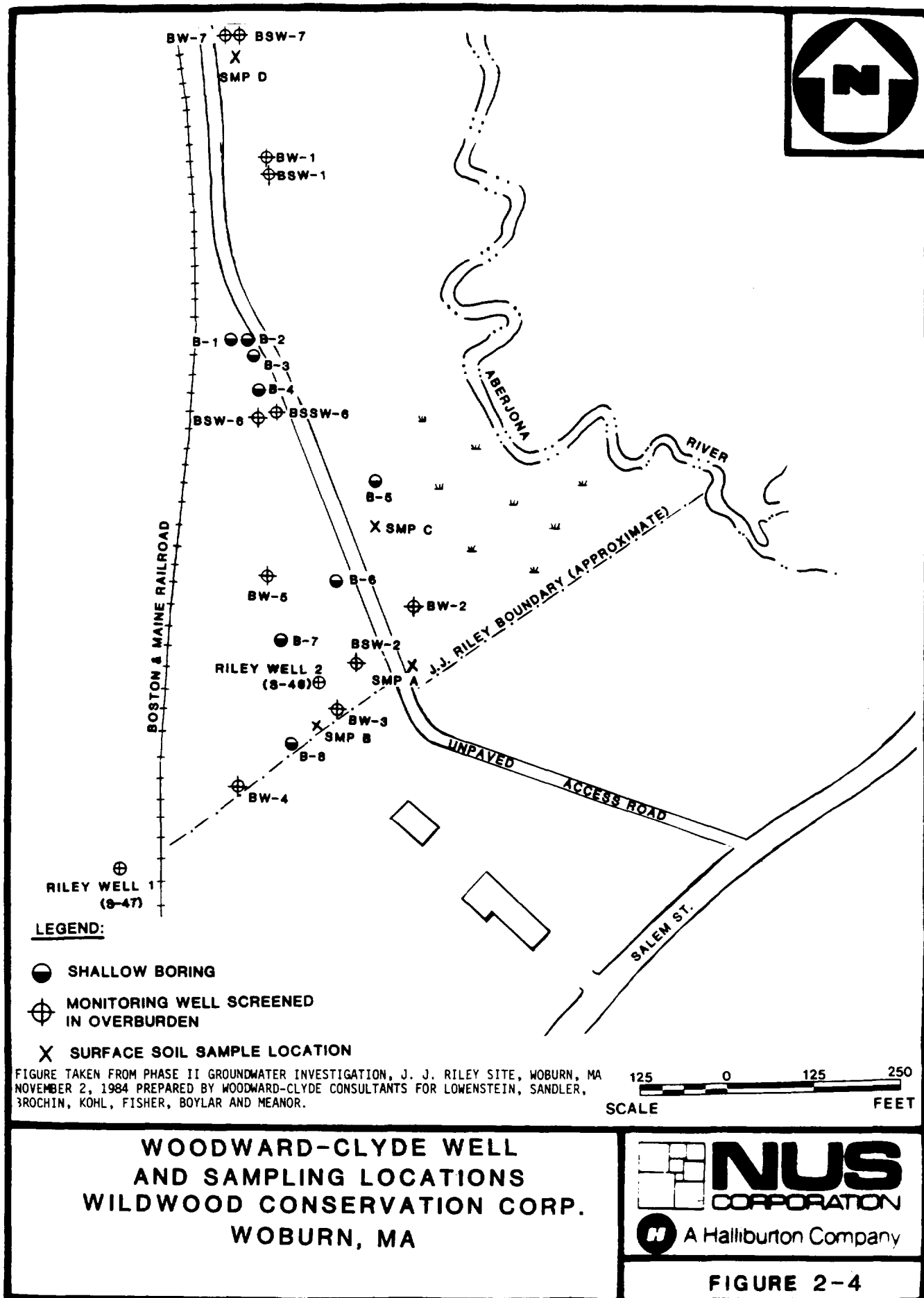
no. 2), an overburden well located on the undeveloped 16 acre parcel east of the Boston and Maine railroad tracks. These findings prompted EPA to issue an administrative order pursuant to RCRA Section 3013 to Beatrice Foods, Inc. site owners at the time, to study the potential sources for the groundwater contamination found in Well S46.

The WCC investigations were conducted in two phases and included the following:

- Acquisition and review of historical aerial photography of John J. Riley property
- A soil boring program to determine the presence or absence of soil contamination
- Installation of groundwater monitoring wells and subsequent groundwater sampling and analysis
- Performance of an aquifer test

The objectives of WCC's investigations were to determine background water quality, to identify the probable source of contaminated groundwater at the Beatrice Foods site, and to determine whether past uncontrolled dumping at the Beatrice Foods site property contributed to the degradation of groundwater quality in the Aberjona River Valley (Woodward-Clyde, 1984a and 1984b).

Seven groundwater monitoring wells were installed by WCC in September, 1983, and four additional wells were installed in July, 1984. In this report, groundwater monitoring wells installed by Woodward-Clyde Consultants for Beatrice Foods, Inc. are denoted as BW (Beatrice well overburden) and BSW (Beatrice shallow overburden well), or BSSW (Beatrice well located at or near the water table) (Figure 2-4). The wells were screened at various depths in the forty feet of overburden. The well logs for these wells are presented in Appendix B. Nine soil borings were advanced in Phase I. Soil samples collected from these borings as



well as surface and subsurface soil samples collected during Phase II were analyzed for 1,1,1-TCA, trans-1,2-DCE, methylene chloride, TETRA, and TCE. Groundwater samples were also analyzed for these selected volatile organic compounds.

Figure 2-4 depicts the locations of WCC's groundwater monitoring wells, test borings and surface soil samples. Table 2-3 summarizes Phase I soil boring analytical data and Table 2-4 summarizes Phase II sampling data. The data demonstrate that surface and subsurface volatile contamination of soils exists on site. The highest concentration of contamination was 46,000 ppb of 1,1,1-TCA for surface soils (less than 6" deep) and 4,900 ppb of TCE for surface soils.

Groundwater contamination by volatile organic compounds is evidenced at most of WCC's wells, with the highest concentrations at wells BSSW6 and BSW6. All volatile organic samples were analyzed by Measurement Sciences Corporation according to EPA Method 601. The analytical results were used in comparison with NUS/FIT data analyzed by an EPA contract laboratory, to develop a reliable data base for the writing of this report.

WCC conducted a fifteen hour aquifer test by pumping the John J. Riley Production Well No. 2 (S46) at a rate between 570 to 770 gpm in July, 1984. S46 is a 24 inch diameter industrial well screened from 41 feet to 51 feet below ground surface in a sand and gravel stratum of the Aberjona aquifer. A cone of depression was reported to extend eastward to well BW2, northward to well BW6, westward to well BW4, and southward to well BW3. WCC concluded that the groundwater beneath the Wildwood Conservation Corporation site is captured by the production well. They further suggested that the Aberjona River and the adjacent swamp are recharge boundaries and that a cone of depression from the Riley production well does not extend under the Aberjona River system (Woodward-Clyde Consultants, 1984b).

From a review of historic aerial photography (1966 to 1983), WCC suggested that the Beatrice Foods site had been used for storage of large tanks and perhaps drums

TABLE 2-3
PHASE I ANALYTICAL DATA FROM
SOIL BORING PROGRAM CONDUCTED
BY WOODWARD-CLYDE CONSULTANTS
AT THE WILDWOOD CONSERVATION CORPORATION SITE

Sample ID: Soil Sample #1 at	B-7	#5	B-6
#2	B-8	#6	B-3
#3	B-4	#7	BSW-6
#4	B-5	#8	Surface Sample BW-3

ANALYTICAL PARAMETERS	#1	#2	#3	#4	#5	#6	#7	#8
				(ppb)				
Methylene Chloride	<10	<10	<10	<10	<10	<10	<10	<100
1,2-Dichloroethane	<10	<10	<10	<10	<10	<10	<10	<100
1,1,1-Trichloroethane	<5	<5	<5	<5	<5	<5	<5	<50
Trichloroethene	<5	<5	2100	<5	<5	<5	150	4900
Tetrachloroethene	<5	<5	20	<5	<5	<5	6	<50

Note: 1. Table taken Geohydrology and Groundwater Contamination, J.J. Riley Site, Woburn, Massachusetts, 31, January 1984 prepared by Woodward-Clyde Consultants for Lowenstein, Sandler, Brochin, Kohl, Fisher, Boylan & Meanor.

2. Woodward-Clyde refers to the Wildwood Conservation Corporation site (EPA site name) as the J.J. Riley Site (former owner).

TABLE 21⁴
PHASE II ANALYTICAL DATA FROM
GROUNDWATER AND SOIL SAMPLING
CONDUCTED BY WOODWARD-CLYDE
CONSULTANTS AT THE WILDWOOD CONSERVATION CORPORATION SITE

Sample	Date	Tetrachloro- ethene	Methylene- chloride	Trichloro- ethene	1,1,1-Tri- chloroethane	Trans-1,2- dichloroethene	Total analyzed volatile
Water (ppb)							
RSW-1	7/16	5.9	ND	270	3.5	ND	279.4
	7/30	1.6	ND	460	1.4	ND	463
RW-1	7/16	ND	ND	ND	trace	ND	trace
	7/30	ND	ND	ND	ND	ND	ND
RSW-2	7/16	ND	ND	1.0	ND	ND	1.0
	7/30	ND	ND	5.9	ND	ND	5.9
RW-2	7/30	ND	ND	300	ND	ND	300
RW-3	7/16	2.7	ND	1.5	33	23	73.7
	7/30	6.5	ND	53	41	30	130.5
RW-4	7/30	ND	ND	ND	ND	ND	ND
RW-5	7/16	ND	ND	190	33	ND	193.3
	7/30	ND	ND	340	1.0	ND	340.0
RSW-6	7/30	67	ND	1,900	2,500	2,500	6,967
RSSW-6	7/30	31	68	230,000	7,200	5,100	242,399
RSW-7	7/30	92	ND	650	ND	130	872
RW-7	7/30	ND	ND	120	ND	ND	120
Soils (ppb)							
SMP-A	7/25	36,000	580	18,000	46,000	21,000	121,580
SMP-B	7/27	ND	ND	36	ND	ND	36
SMP-C	7/27	ND	ND	ND	ND	ND	ND
SMP-D	7/27	ND	ND	ND	ND	ND	ND
Subsurface Soils (ppb)							
RSW-6 (5-7')	7/16	1.5	ND	170	ND	ND	171
RSW-7 (8-10')	7/25	ND	ND	ND	ND	ND	ND
RSW-7 (8-10')	7/25	ND	ND	ND	ND	ND	ND

Notes: 1. Table taken from Phase II Groundwater Investigation, J.J. Riley site, Woburn, Massachusetts, 2 November 1984 prepared by Woodward-Clyde Consultants for Lowenstein, Sandler, Brochin, Kohl, Fisher, Boylan and Meanor.

2. Woodward-Clyde refers to the Wildwood Conservation Corporation site (EPA site name) as the J.J. Riley Site (former owner).

3. ND - Not Detected

by the two companies located south of the property: Whitney Barrel Company and Murphy Waste Oil. The existing unpaved access road was evident in past aerial photographs as were additional trails leading from both the Whitney Barrel and Murphy Waste Oil properties. Greater use of these trails was apparent from 1966 to 1969 than in 1978 to 1983 (Woodward-Clyde, 1984a).

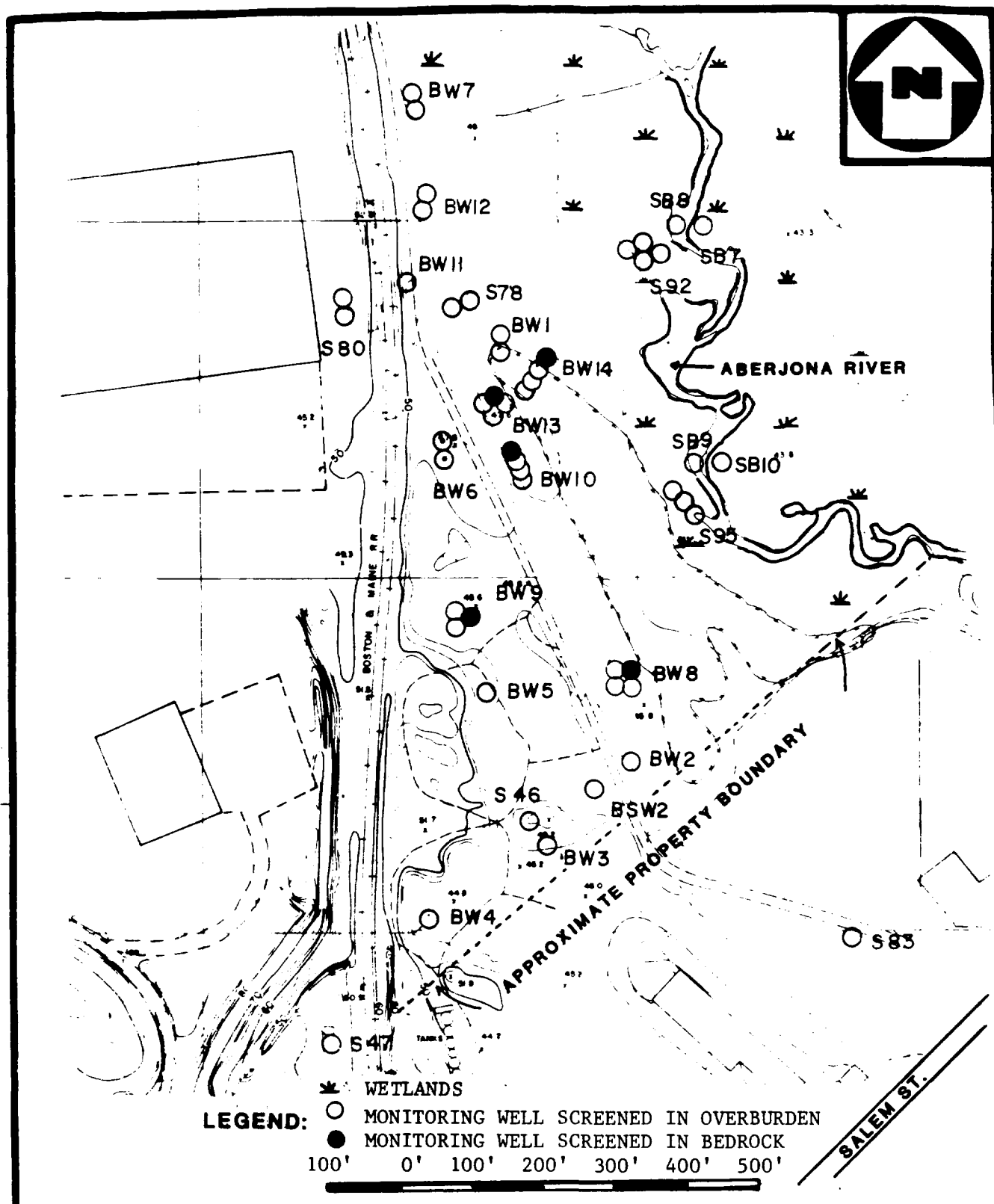
WCC concluded that groundwater contamination at the Beatrice Foods site was primarily due to onsite sources. WCC also suggested that additional offsite sources located north or west of the property may have also contributed groundwater contamination, however, they provided no evidence for this theory.

In the fall of 1985, additional groundwater monitoring wells were installed at eight locations (BW7 through BW14) by Weston Geophysical of Westboro, Massachusetts for Schlichtmann, Conway and Crowley (attorneys for the plaintiffs in the civil law suit against W.R. Grace and Beatrice Foods). Figure 2-5 depicts new well locations in relation to those wells installed by WCC. Each well location consists of two to four wells. The well logs to these wells are presented in Appendix B. Groundwater sampling was conducted of all wells by WCC in November, 1985. The samples were analyzed by ERCO Laboratories. The results are presented in Appendix C (Tables 3 and 4).

A number of volatile organic compounds were detected in these samples. The most prevalent and widespread contaminants were TCE, trans-1,2-DCE, 1,1,1-TCA, and 1,1-dichloroethane. High concentrations of contamination were detected at wells BSW6 (100,000 ppb TCE), BSSW6 (430,000 ppb TCE and 10,000 ppb 1,1,1-TCA), BSW9 (12,000 ppb TCE), BW13 (54,000 ppb TCE), and BW14 (54,000 TCE). These results will be discussed further in Chapter 5.0.

2.6 Investigations Conducted at UniFirst Corporation

Environmental Research and Technology (ERT) was contracted by UniFirst Corporation (formerly Interstate Uniform Corporation) to conduct an investigation in response to an administrative order issued by EPA in September, 1983. The



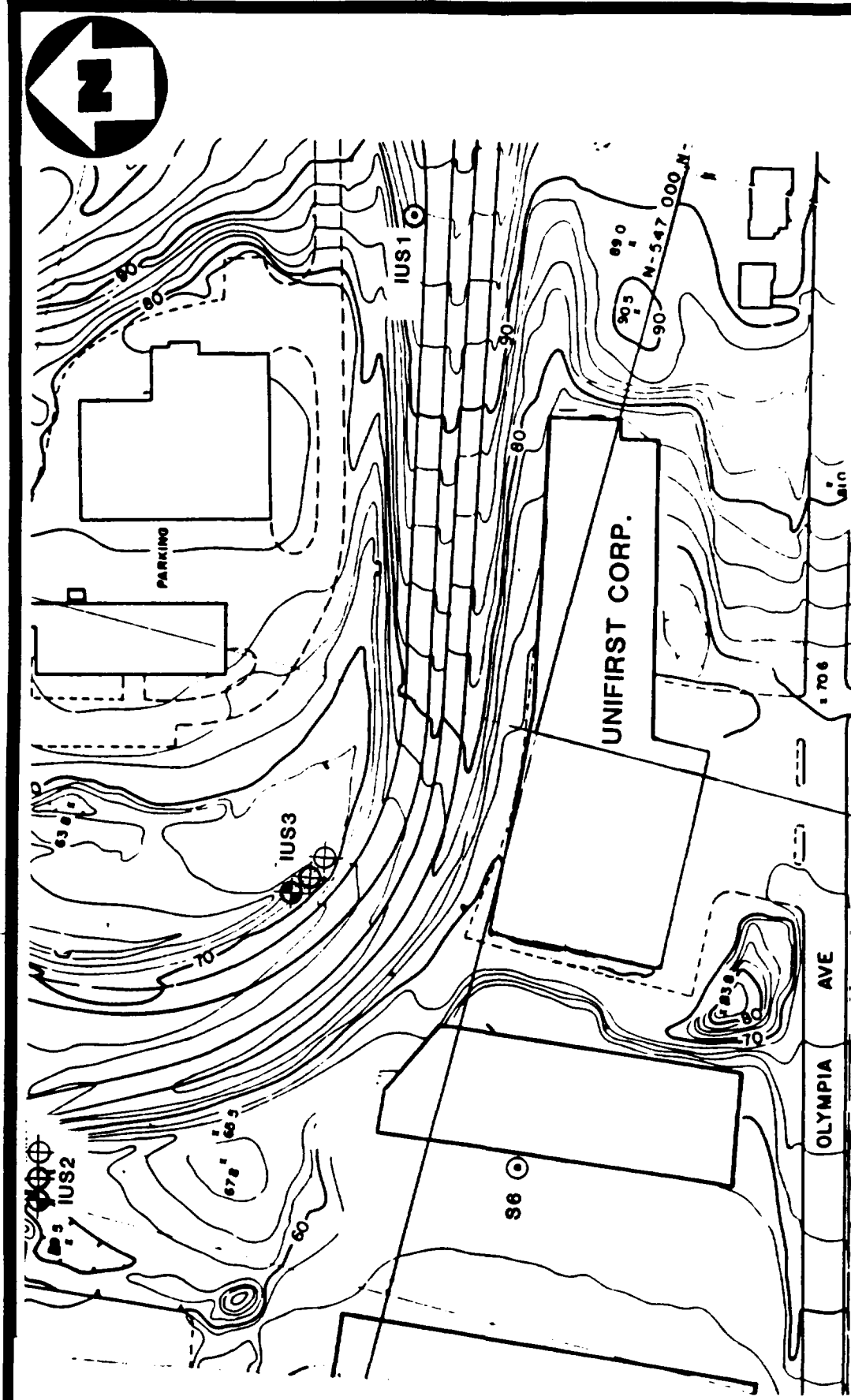
purpose of the investigation was to describe the historical development of the UniFirst site and to determine the potential of the UniFirst site as a source of tetrachloroethene (TETRA) contamination to well S6 located just west of the facility (ERT, 1984). UniFirst Corporation is a uniform service company that utilizes TETRA in its dry cleaning operation.

The consent order between EPA and UniFirst stipulated that UniFirst would determine whether a source of TETRA groundwater contamination existed upgradient of its facility. If levels of TETRA greater than 50 ppb were detected upgradient of the UniFirst site, no further investigation would be required by EPA. If levels less than 50 ppb were detected upgradient, UniFirst would be required by EPA to submit a plan for further investigation.

ERT installed seven groundwater monitoring wells at three locations upgradient of the UniFirst facility and well S6 between the Fall of 1984 and Spring 1985 (Figure 2-6). The well logs for these wells are presented in Appendix B. Volatile organic compounds were not detected by ERT or NUS/FIT in any of these wells (Table 2-5).

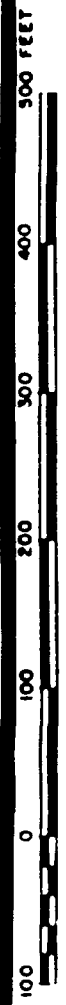
ERT described UniFirst's use and storage of TETRA as follows:

- five to six 55-gallon drums per year were used during 1966 to 1968 for their dry cleaning operation
- TETRA was stored in a 5,000 gallon above ground tank from 1977 to 1982 for transfer to tank trucks for distribution to other facilities.
- UniFirst officials reported only one significant spill in 1979 which was contained and cleaned up. UniFirst officials also contend that any spilled liquid would have ultimately been discharged to the municipal sewer.
- Waste water was discharged to the municipal sewer and still bottom waste (five gallons of diatomaceous earth filter medium per year containing 20%



LEGEND:

- ⊙ BEDROCK WELL
- ⊕ SHALLOW WELL
- ⊙ WELL SCREENED IN OVERBURDEN AND BEDROCK



SCALE 1" = 200'

**WELL LOCATIONS
UNIFIRST SITE
WOBBURN, MA**



FIGURE 2-6

TABLE 2-5
NUS/FIT VOLATILE ORGANIC ANALYTICAL RESULTS (PPB)
OF GROUNDWATER SAMPLES
MAY 1984

Sample Location	IUS- ID*	IUS-2S	IUS-2M	IUS-2D	IUS-3S	IUS-3M	IUS-3D
Sample Number		76856	76857	76854-55	76858	76861	76860
Traffic Report Number		A2752	A2753	A2750-51	A2754	1A2757	A2756

Volatile Compounds	CRDL						
Chloromethane	10	-	-	-	-	-	-
Bromomethane	10	-	-	-	-	-	-
Vinyl Chloride	10	-	-	-	-	-	-
Chloroethane	10	-	-	-	-	-	-
Methylene Chloride	5	-	-	-	-	-	-
Acetone	10	-	-	-	-	-	-
Carbon Disulfide	5	-	-	-	-	-	-
1,1-Dichloroethene	5	-	-	-	-	-	-
1,1-Dichloroethane	5	-	-	-	-	-	-
trans-1,2-Dichloroethene	5	-	-	-	-	-	-
Chloroform	5	-	-	-	-	-	-
1,2-Dichloroethane	5	-	-	-	-	-	-
2-Butanone	10	-	-	-	-	-	-
1,1,1-Trichloroethane	5	-	-	-	-	-	-
Carbon Tetrachloride	5	-	-	-	-	-	-
Vinyl Acetate	10	-	-	-	-	-	-
Bromodichloromethane	5	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	5	-	-	-	-	-	-
1,2-Dichloropropane	5	-	-	-	-	-	-
trans-1,3-Dichloropropane	5	-	-	-	-	-	-
Trichloroethene	5	-	-	-	-	-	-
Dibromochloromethane	5	-	-	-	-	-	-
1,1,2-Trichloroethane	5	-	-	-	-	-	-
Benzene	5	-	-	-	-	-	-
cis-1,3-Dichloropropene	5	-	-	-	-	-	-
2-Chloroethylvinylether	10	-	-	-	-	-	-
Bromoform	5	-	-	-	-	-	-
2-Hexanone	10	-	-	-	-	-	-
4-Methyl-2-Pentanone	10	-	-	-	-	-	-
Tetrachloroethene	5	-	-	-	-	-	-
Toluene	5	-	-	-	-	-	-
Chlorobenzene	5	-	-	-	-	-	-
Ethylbenzene	5	-	-	-	-	-	-
Styrene	5	-	-	-	-	-	-
Total Xylenes	5	-	-	-	-	-	-

- - Indicates the compound was not detected

CRDL - Contract Required Detection Limit

* - Analyzed by NUS/FIT screening techniques utilizing a Photovac 10A10 Gas Chromatograph

TETRA by weight) was stored in drums and transported to a municipal landfill for disposal, or disposed of in a dumpster which was removed by a commercial refuse hauler.

- No onsite disposal of waste was reported.

ERT concluded that the "potential is very low that the UniFirst site is the source of tetrachloroethene contamination in groundwater". ERT proposed that the contamination found at well S6 originates in bedrock and that other sources of contamination may exist in addition to or instead of UniFirst due to the presence of tetrachloroethene groundwater contamination in locations other than S6. ERT proposed that no further work be conducted at the site. Whether the contamination at well S6 originated in bedrock is undetermined, as the well is screened in both overburden and bedrock.

2.7 Juniper Development Group Investigation

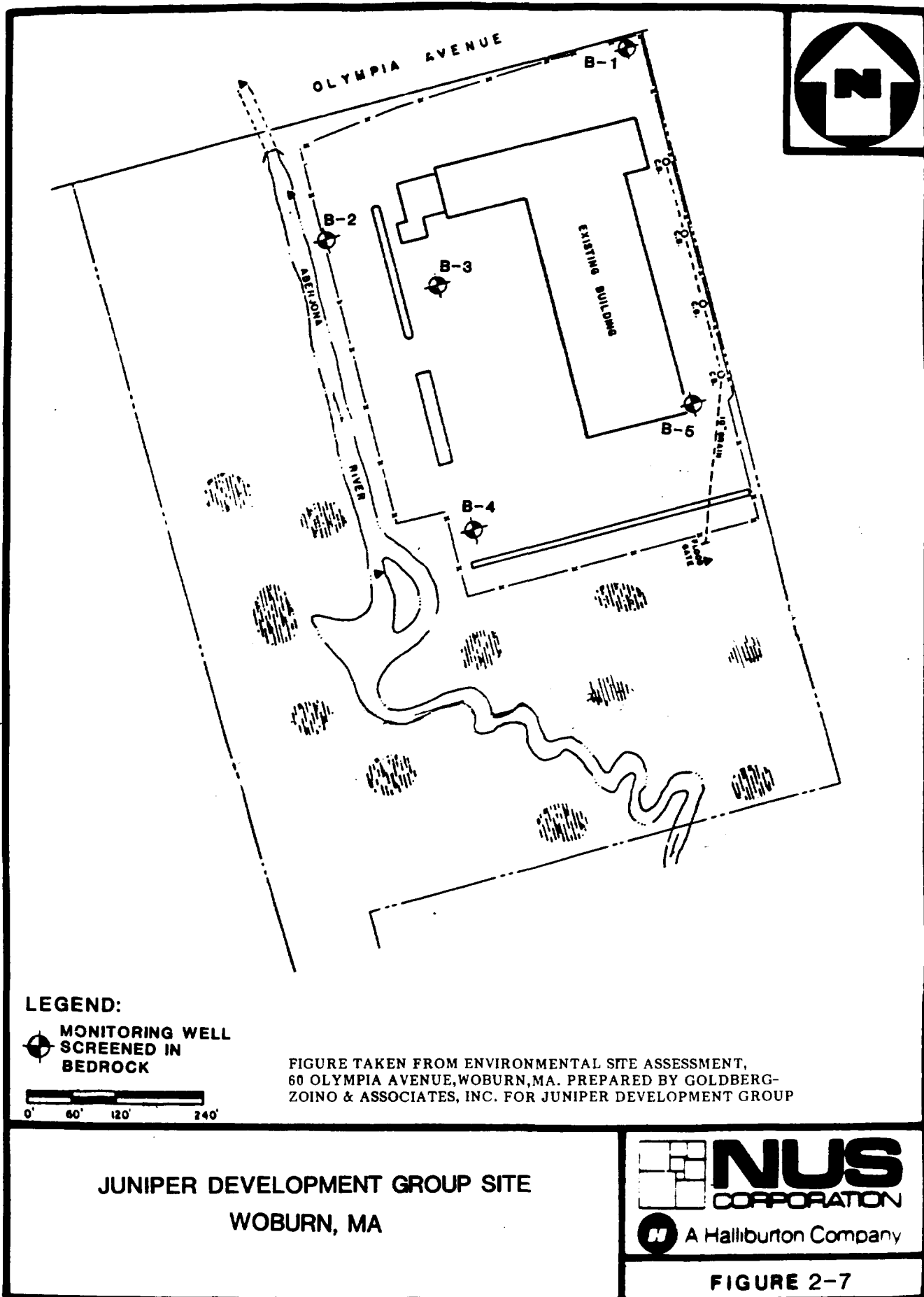
An environmental assessment of 60 Olympia Avenue, Woburn, Massachusetts, pursuant to Massachusetts General Laws Chapter 21E was conducted by Goldberg-Zoino and Associates, Inc. (GZA) (Newton Upper Falls, Massachusetts) in February, 1985 for Juniper Development Group (Winchester, Massachusetts). The area investigated consisted of approximately 21 acres owned by the Juniper Development Group and includes an eight acre parcel (60 Olympia Avenue) utilized as a truck terminal (Figure 2-1). The remaining acreage consists of wetlands along the Aberjona River south and west of the trucking terminal. The site has been used in the past for transportation and trucking operations. An underground storage tank found to contain water at the time of site acquisition was removed in July, 1984 by Juniper Development Group and replaced with two new underground tanks for the storage of diesel fuel. A past owner of the site, Hemingway Transport Company, reported to the DEQE in November, 1982 that 17 drums containing "oily type semi-solid waste" had been deposited on their property. GZA noted that no record of their removal was found (GZA, 1985).

GZA installed five overburden groundwater monitoring wells on the trucking terminal property along the western and southern boundaries, and in the northeast corner (Figure 2-7). Groundwater samples were collected from the monitoring wells and analyzed for volatile organic compounds. GZA reported that benzene (170 ppb); toluene (540 ppb); ethylbenzene (150 ppb); xylenes (750 ppb); tetrachloroethene (trace levels); 1,1,1-trichloroethane (trace levels); and trichloroethene (trace levels) were detected in groundwater from the site. GZA suggested that the aromatic volatile organic compounds detected (benzene, toluene, xylenes and ethylbenzene) were constituents of gasoline and may be present because of prior site activity. The wells these constituents were found in were located downgradient from the removed leaking underground tank (GZA, 1985).

On September 17, 1985, EPA conducted additional sampling on Juniper Development Group property southwest of the trucking terminal in between the Aberjona River and the railroad tracks (Figure 2-1). Approximately ten rusted drums and a small pile of pesticide label caps were found at this location by EPA. Soil samples adjacent to the drums and samples of drums' contents were collected and analyzed for volatile and extractable organic compounds. High levels of chlordane (5.1%) and polychlorinated biphenyls (PCBs) (3.1%) were detected in one soil sample while chlorinated volatile organic compounds (TCE and TETRA) were detected in all samples. A yellow waxy material, collected from one of the drums, was determined to be a petroleum-based grease (Granz, 1986). These drums and surrounding soil were removed by the present owner under an EPA Administrative Order in December, 1985.

2.8 EPA/USGS Aquifer Test

In the fall of 1985, EPA, through a cooperative agreement with the USGS, designed and implemented an aquifer test of Wells G & H which included installation of groundwater monitoring wells in the center of the Aberjona River Valley. These wells were installed by the US Army Corps of Engineers (COE) and are denoted as S87-S97 on Plate 1. Groundwater samples were collected from these and other



wells in the study area for volatile organic compound analysis in May and November, 1985 by GeoEnvironmental and Woodward-Clyde Consultants. EPA collected split samples of GeoEnvironmental's November sampling round for Contract Laboratory Program (CLP) volatile organic compound analysis. All of these results are presented in Appendix C (Tables 5 and 6). Those samples analyzed by ETC were collected by GeoEnvironmental; those analyzed by ERCO were collected by Woodward-Clyde, while those analyzed by Compuchem were collected by EPA. The samples collected by EPA were analyzed through the CLP. The CLP data was validated according to EPA protocols, however, a more limited quality control review was conducted on the non-CLP data. In addition, this report does not address the integrity of the sampling points nor whether proper sampling plans, procedures or quality control were employed by other parties in collection of these samples.

A number of volatile organic compounds were detected including: TCE; TETRA; 1,1,1-TCA; and trans-1,2-DCE. These results will be further discussed relative to distribution of volatile organic compounds in Chapter 5.0.

3.0 NUS/FIT FIELD INVESTIGATION METHODOLOGY

To meet the objectives of the Remedial Investigation, as described in Section 1.2, a multi-phased investigative approach was required. The objectives were achieved by NUS/FIT with the completion of the following major tasks, conducted over a sixteen month period from July, 1984 through November, 1985:

- Initial sample collection utilizing NUS/FIT volatile organic headspace analysis.
- Installation of 55 groundwater monitoring wells at 24 locations including soil borings and bedrock corings.
- In-situ (field) permeability testing and laboratory grain size analysis.
- Updating of the basemap conducted by the Environmental Photographic Interpretation Center (EPIC), United States Geological Survey (USGS) and NUS to reflect current planimetric features.
- Surveying of newly installed and pre-existing monitoring wells.
- Performance of three groundwater and surface water sampling rounds for CLP analysis.
- Measurement of water levels in all monitoring wells.
- Performance of a magnetometry survey.
- Installation of piezometers in support of EPA/USGS aquifer test.

The methods and procedures pertinent to each task and a discussion of the data obtained are briefly summarized in the following sections. Detailed work plans for each task were submitted to EPA for review prior to any field work. Ambient air monitoring was conducted with a Foxboro Century Systems Organic Vapor Analyzer (OVA) Model 128 or an HNu Systems PI101 Photoionization Detector during all field activities. No levels of ambient vapors were detected above background during any field activity conducted in the study area. Evaluation of the data is presented in Sections 4.0 and 5.0. Much of the raw data are presented in the appendices, but are discussed throughout the report. More detailed descriptions of the methodology (summarized below) are presented in Appendix D.

3.1 Initial Sampling Round

NUS/FIT conducted an initial sampling round of the Wells G & H aquifer area between July 17 and August 20, 1984.

This provided a comprehensive and contemporaneous sampling of the study area. Table 3-1 presents pertinent data concerning the 52 samples, including the duplicates and blanks that were collected from 34 monitoring wells, three surface water locations (designated by SW prefix), and three sediment locations (designated by SS prefix) (Table 3-1). Sampling locations are depicted in Figures 3-1A and B. Due to the limited availability of sample analytical slots through the Contract Laboratory Program, samples were collected for NUS/FIT screening on a Photovac Gas Chromatograph model 10A10 for volatile organic compounds. A discussion of this technique is presented in Appendix D. The analytical results served to establish the current extent of contamination and further, aided in the subsequent placement of monitoring wells. It should be noted that all of the wells and surface water locations included in the initial sampling round were later resampled for CLP gas chromatography/mass spectrometry (GC/MS) analysis. Analytical results of this and subsequent sampling rounds are discussed in Chapter 5 and are presented in Appendix G.

**TABLE 3-1
NUS/FIT INITIAL SAMPLING ROUND (JULY-AUGUST, 1984)
SAMPLE COLLECTION SUMMARY**

Sample Location	Sample No.	Date Sampled	Time Sampled	Purging Method	Total Amount Purged (Gallons)	pH/Conductivity*
BSW-2	76274	07-17-84	1030	Gas Pump	10.0	Vol. 1 = 5.8/320 Vol. 2 = 6.2/340 Vol. 3 = 6.5/340 Vol. 4 = 6.5/340 Vol. 5 = 6.5/355
BW-3	76275	07-17-84	1050	Air Lift Pump	13.0	Vol. 1 = 7.0/855 Vol. 2 = 5.0/900 Vol. 3 = 5.4/900
BW-3 Duplicate	76276	07-17-84	1050	Air Lift Pump	13.0	Vol. 1 = 7.0/855 Vol. 2 = 5.0/900 Vol. 3 = 5.4/900
S-46	76277	07-17-84	1105	NA	4 minutes	Vol. 1 = 7.4/680 Vol. 2 = NA Vol. 3 = NA
BW-5	77501	07-17-84	1215	Hand Bailing	10.8	Vol. 1 = 8.0/720 Vol. 2 = 8.4/720 Vol. 3 = 8.4/710
BSW-1	77502	07-17-84	1300	Hand Bailing	10.5	Vol. 1 = 8.4/300 Vol. 2 = 8.4/300 Vol. 3 = 8.4/300
BW-1	77503	07-17-84	1315	Hand Bailing	13.8	Vol. 1 = 7.8/340 Vol. 2 = 8.3/320 Vol. 3 = 8.4/320
OW-7	77515	07-19-84	0920	Gas Pump	49.05	Vol. 1 = 6.4/340 Vol. 2 = 6.0/350 Vol. 3 = 6.0/370
OW-7 Duplicate	77517	07-19-84	0920	Gas Pump	49.05	Vol. 1 = 6.4/340 Vol. 2 = 6.0/350 Vol. 3 = 6.0/370
OW-19	77516	07-19-84	1025	Submersible Pump	500	Vol. 5 = 6.8/500*
OW19A	77520	07-19-84	1115	Gas Pump	69.0	Vol. 1 = 6.4/350 Vol. 2 = 6.4/360 Vol. 3 = 6.4/350

TABLE 3-1
NUS/FIT INITIAL SAMPLING ROUND (JULY-AUGUST, 1984)
SAMPLE COLLECTION SUMMARY
PAGE TWO

Sample Location	Sample No.	Date Sampled	Time Sampled	Purging Method	Total Amount Purged (Gallons)	pH/Conductivity
OW20	77522	07-19-84	1205	Submersible Pump	300	Vol. 3 = 5.8/560*
OW-20A	77521	07-19-84	1240	Gas Pump	66.0	Vol. 1 = 8.1/1100 Vol. 2 = 7.8/1100 Vol. 3 = 8.0/1100
S-60	77519	07-20-84	1045	Hand Bailing	6.56	Vol. 1 = 9.2/2200 Vol. 2 = 10.0/2000 Vol. 3 = 9.8/2000 Vol. 4 = 9.2/2000
S-6	77565	07-20-84	1240	Gas Pump	21.9	Vol. 1 = 8.0/1200 Vol. 2 = 7.8/1200 Vol. 3 = 7.8/1200
S-5	77566	07-20-84	1317	Hand Bailing	18.0	Vol. 1 = 8.4/1200 Vol. 2 = 8.4/1250 Vol. 3 = 8.4/1200
S-8	77568	07-20-84	1500	Gas Pump	34.2	Vol. 1 = 7.2/420 Vol. 2 = 7.2/420 Vol. 3 = 7.4/420
S-8 Duplicate	77569	07-20-84	1500	Gas Pump	34.2	Vol. 1 = 7.2/420 Vol. 2 = 7.2/420 Vol. 3 = 7.4/420
OW-8	77567	07-20-84	1515	Submersible Pump	180.0	Vol. 2 = 8.4/540*
SW-01	77570	07-25-84	0855	NA	NA	7.8/610
SS-01	77571	07-25-84	0905	NA	NA	NA
SW-04	77572	07-25-84	0955	NA	NA	7.5/550
SS-04	77573	07-25-84	1000	NA	NA	NA
SW-02	77574	07-25-84	1200	NA	NA	NA
SW-02 Duplicate	77575	07-25-84	1200	NA	NA	NA

**TABLE 3-1
NUS/FIT INITIAL SAMPLING ROUND (JULY-AUGUST, 1984)
SAMPLE COLLECTION SUMMARY
PAGE THREE**

Sample Location	Sample No.	Date Sampled	Time Sampled	Purging Method	Total Amount Purged (Gallons)	pH/Conductivity
SS-02	77576	07-25-84	1200	NA	NA	NA
SS-02 Duplicate	77577	07-25-84	1200	NA	NA	NA
S-11	77578	07-25-84	1445	Gas Pump	23.0	Vol. 1 = 7.6/660 Vol. 2 = 5.0/670 Vol. 3 = 4.0/670
GW-3S	77579	07-26-84	1140	Hand Bailing	9.0	Vol. 1 = 6.3/NM Vol. 2 = 5.8/NM Vol. 3 = 5.9/NM
GW-3S Duplicate	77580	07-26-84	1140	Hand Bailing	9.0	Vol. 1 = 6.3/NM Vol. 2 = 5.8/NM Vol. 3 = 5.9/NM
GW-3D	76270	07-26-84	1200	Hand Bailing	21.0	Vol. 1 = 6.2/NM Vol. 2 = 6.5/NM Vol. 3 = 7.0/NM
GW-4S	77581	07-26-84	1455	Hand Bailing	7.8	Vol. 1 = 6.2/NM Vol. 2 = 7.0/NM Vol. 3 = 6.6/NM
GW-4D	77582	07-26-84	1505	Hand Bailing	10.4	Vol. 1 = 7.0/NM Vol. 2 = 6.5/NM
S-22	11210	08-20-84	1150	Hand Bailing	9.0	NM
S-21	11211	08-20-84	1250	Hand Bailing	6.6	NM
BSW-1	77585	07-28-84	1235	Gas Pump	**	NM
BW-1	77586	07-28-84	1230	Gas Pump	**	NM
BSW-2	77587	07-28-84	1545	Gas Pump	**	NM
BW-2	77588	07-28-84	1500	Gas Pump	**	NM
BW-3	77589	07-28-84	1615	Gas Pump	**	NM
BW-4	77590	07-28-84	1630	Gas Pump	**	NM
BW-5	77591	07-28-84	1430	Gas Pump	**	NM

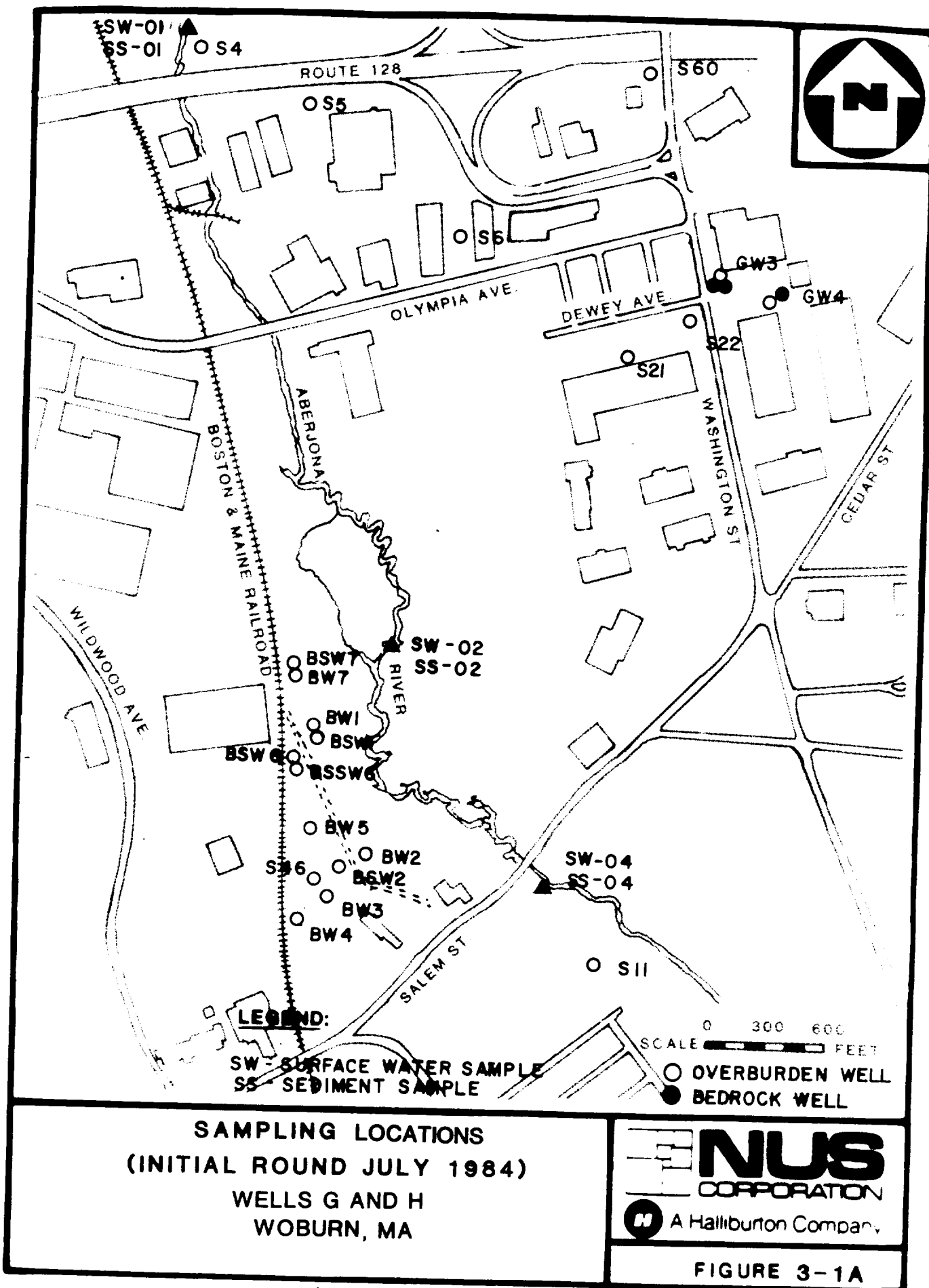
TABLE 3-1
NUS/FIT INITIAL SAMPLING ROUND (JULY-AUGUST, 1984)
SAMPLE COLLECTION SUMMARY
PAGE FOUR

Sample Location	Sample No.	Date Sampled	Time Sampled	Purging Method	Total Amount Purged (Gallons)	pH/Conductivity
BSSW-6	77592	07-28-84	1300	Gas Pump	**	NM
BSW-6	77593	07-28-84	1315	Gas Pump	**	NM
BSW-7	77594	07-28-84	1215	Gas Pump	**	NM
BW-7	77595	07-28-84	1215	Gas Pump	**	NM
Blank	77504	7-17-84	1400	NA	NA	NA
Blank	77518	7-19-84	1200	NA	NA	NA
Blank	77611	7-20-84	1515	NA	NA	NA
Blank	76269	7-25-84	1630	NA	NA	NA
Blank	77583	7-26-84	1130	NA	NA	NA
Blank	11212	8-20-84	1400	NA	NA	NA

<u>Summary</u>	Volatile Samples	Duplicate Samples
Monitoring Well Locations	34	4
Surface Water Locations	3	1
Sediment Locations	3	1
Blanks	6	-
Total	<u>46</u>	<u>6</u>

LEGEND

- * - pH (standards) conductivity (microhos/cm) were measured after every well volume. Each measurement is given.
- ** - Split samples collected by Woodward & Clyde Consultants. A minimum of three (3) well volumes were purged before sampling.
- NA - Not Applicable
- NM - Not Measured
- SW - Surface water sample
- SS - Sediment sample



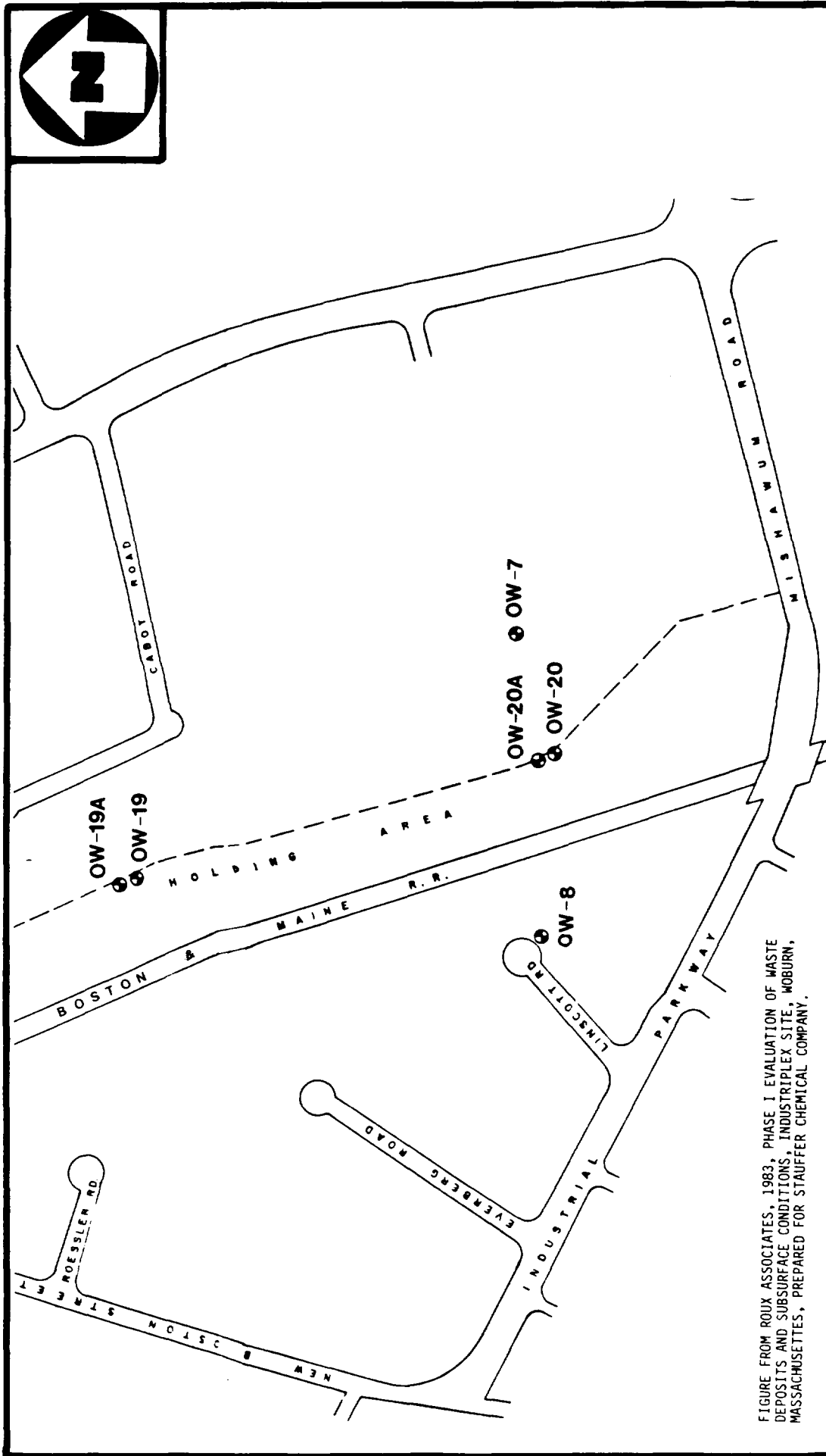


FIGURE FROM ROUX ASSOCIATES, 1983, PHASE I EVALUATION OF WASTE DEPOSITS AND SUBSURFACE CONDITIONS, INDUSTRIPLEX SITE, WOBURN, MASSACHUSETTES, PREPARED FOR STAUFFER CHEMICAL COMPANY.



SAMPLING LOCATIONS
NORTH OF MISHAWUM ROAD
INITIAL ROUND (JULY 1984)
FINAL ROUNDS (APRIL-JUNE, 1985)
WOBURN, MA



FIGURE 3-1B

3.1.1 Groundwater Sampling

Groundwater samples were collected after well purging; a minimum of three well volumes to a maximum of five well volumes were purged. Purging was accomplished by mechanical pump or hand bailing. Conductivity and pH were measured after each well volume to ensure that the samples were representative of the water in the aquifer. Samples were collected with a stainless steel bailer and poured into 44 milliliter (ml) septum-sealed vials. All samples were preserved with mercuric chloride to a final concentration of 16 ppm in the vial. Samples were stored on ice until delivery to the EPA's New England Regional Laboratory in Lexington, Massachusetts. Chain of custody procedures were followed and all sampling equipment was decontaminated prior to sampling and between wells to prevent cross contamination (Appendix D).

Included with the groundwater samples collected by NUS/FIT personnel, are split samples obtained from monitoring wells on the Wildwood Conservation Corporation property (Beatrice Foods property). The split samples were made available through the sampling activities of Woodward-Clyde Consultants on July 27, 1984. Sampling specifics are presented in Table 3-1.

3.1.2 Surface Water Sampling

Three surface water locations (designated by SW prefixes in Table 3-1 and Figure 3-1A) were sampled during the initial sampling round. Samples were collected from downstream, upstream, and in the near vicinity of the Wells G & H site on the Aberjona River. All samples were collected in a grab fashion using a remote sampler with a laboratory cleaned jar attached. New jars were attached between sampling locations to prevent cross contamination. Each sample was poured into two 44 ml septum-sealed glass vials and immediately labelled and placed on ice for preservation. Chain of custody procedures were followed and all sampling equipment was decontaminated prior to sample collection at all sampling locations.

3.1.3 Sediment Sampling

Three sediment samples were also collected along the Aberjona River at locations designated by an SS prefix in Table 3-1 and Figure 3-1A. Where river depth did not allow for direct collection via a stainless steel spatula, the remote sampler was utilized in the manner described above. The laboratory cleaned jar was replaced between collection of the samples. Directly after collection, each 44 ml vial was labelled and placed on ice. Chain of custody procedures were followed and all sampling equipment was decontaminated prior to sample collection at all locations.

3.2 Installation of Groundwater Monitoring Wells

The objectives of groundwater monitoring well installation were to provide:

- direct information on depth to bedrock and to groundwater
- surficial and bedrock geologic data for evaluation of groundwater movement in unconsolidated sediments and bedrock
- information on groundwater conditions in overburden and bedrock
- groundwater sampling locations for evaluation of groundwater and the extent of groundwater contamination.
- data on vertical stratification of groundwater contamination

A total of 55 wells were installed at 24 locations in the Wells G & H study area utilizing either the hollow stem auger drilling method or the drive and wash method (Appendix D). Figure 3-2 depicts the NUS/FIT well locations. Table 3-2 presents a summary of each well's construction.

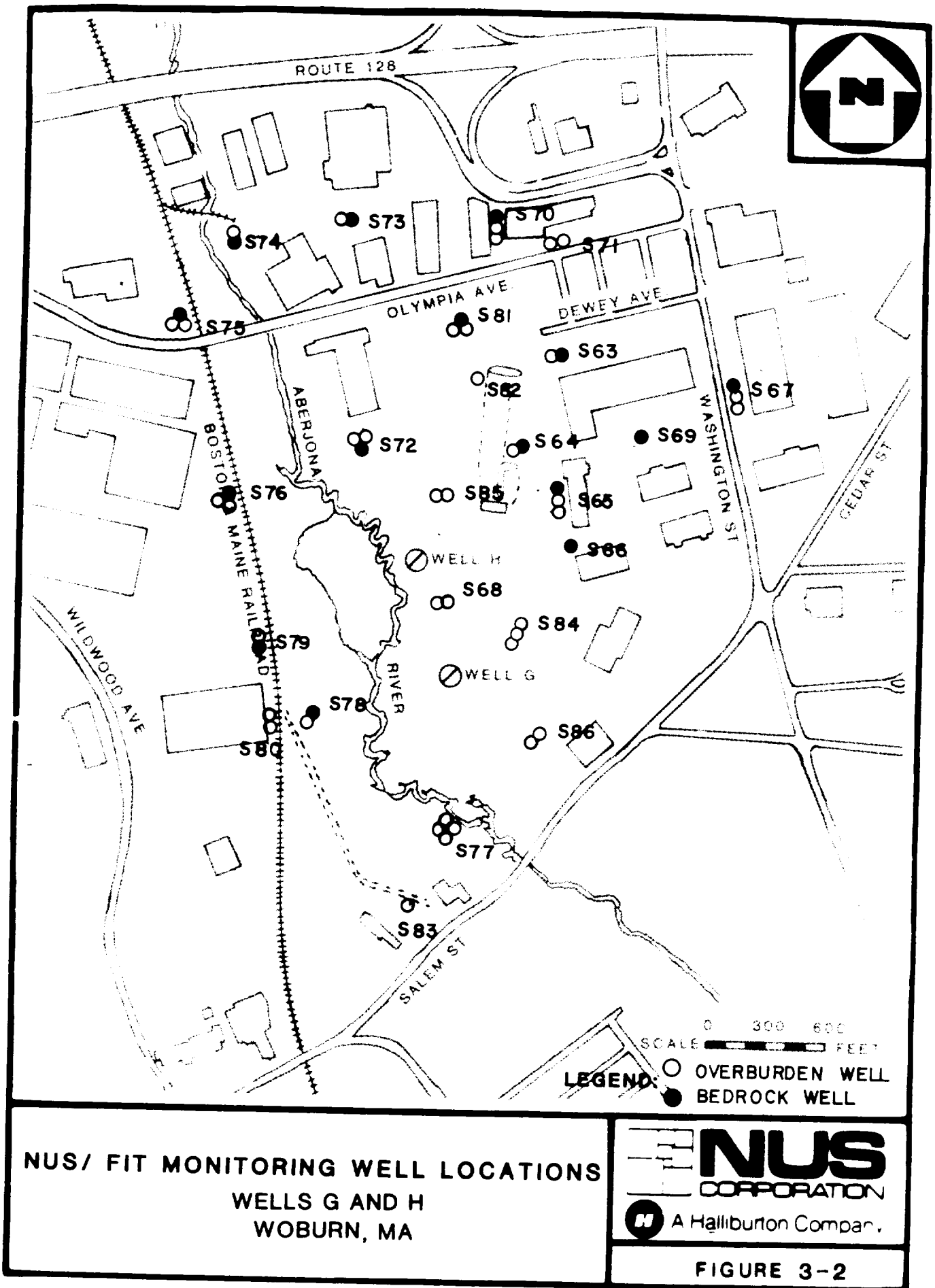
**TABLE 3-2
NUS/FIT WELL CONSTRUCTION SUMMARY**

<u>Well No.</u>	<u>To Bedrock (feet)</u>	<u>Depth Total Depth (feet)</u>	<u>Screened Internal (feet)</u>
S63D	22	36	26-36
S63S	NA	22	12-22
S64D	36	56	41-56
S64M	NA	32	27-32
S64S	NA	15	10-15
S65D	36.4	56.4	41.4-56.4
S65M	NA	37	27-37
S65S	NA	24	4-24
S66D	11.5	34.7	19.7 to 34.7
S67D	54	75	60-75
S67M	NA	43	33-43
S67S	NA	34	24-34
S68M	105	105	55-105
S68S	NA	43.5	14.5-44.5
S69D	35	55	40-55
S70M	NA	62	42-62
S70S	NA	30	15-30
S71D	16.5	42.7	22.7-42.7
S71M	NA	16	11-16
S72D	116	137	122-137
S72M	NA	92.5	54.5-92.5
S72S	NA	54	14-54
S75D	75	95	80-95
S75M	NA	75	50-75
S75S	NA	44	29-44
S76D	130	150	135-150
S76M	NA	75	78-128
S76S	NA	44	15-65

TABLE 3-2
NUS/FIT WELL CONSTRUCTION SUMMARY
PAGE TWO

<u>Well No.</u>	<u>Depth To Bedrock (feet)</u>	<u>Total Depth (feet)</u>	<u>Screened Internal (feet)</u>
S77D	NA	138.5	133.5-138.5
S77M	NA	75	70-75
S77S	NA	30	25-30
S77SS	NA	13	13-18
S78D	90.5	110.5	95.5-110.5
S78S	NA	25	5-25
S79D	107.5	128	113-128
S79M	NA	97	17-97
S80M	NA	65	55-65
S80S	NA	25	45-55
S81D	62	82	67-82
S81M	NA	50	40-50
S81S	NA	20	10-20
S82M	NA	35	25-35
S83M	81.5	80	70-80
S84D	81.5	78	73-78
S84M	NA	45	40-45
S84S	NA	18	13-18
S85M	NA	71	66-71
S85S	NA	30	20-30
S86M	NA	52	47-52
S86S	NA	30	20-30

All measurements made from ground surface.



To prevent the introduction of contamination during the drilling process, all water used during the drilling procedures came from the current Woburn water supply as accessed through a variety of hydrants throughout the study area. Samples were collected from the drillers' water storage tanks and screened in the field on the Foxboro Century Systems Organic Vapor Analyzer (OVA) Model 128 prior to use to ensure that the water was free of (OVA) detectable volatile organic contaminants. OVA screening procedures are described in Appendix D.

Furthermore, all drilling tools used down the borehole (i.e., casing, chuck rods, auger flights) and parts of the drilling rigs extended over the borehole were routinely decontaminated before use at new locations and between boreholes at nested locations to prevent cross contamination (Appendix D).

Split spoon soil samples were collected at five foot intervals or other strata of interest. All samples were stored in labelled jars and retained by NUS/FIT for visual classification. In addition, one septum-sealed 44 ml VOA (volatile organic analysis) vial was partially filled with soil for OVA headspace analysis which was performed in the field by the NUS/FIT onsite chemist in order to detect zones of volatile organic contamination.

Whenever possible, the deepest well in a nested set was drilled first to compile data through volatile organic screening and visual examination of the split spoon samples to assist in subsequent screen placement. The screens were placed to intercept probable zones of contamination in overburden and bedrock.

The wells were constructed using Schedule 80 threaded flush jointed polyvinyl chloride (PVC) with a 1.5 inch inside diameter. The screen slot size for all wells installed was 0.010 inch. The annulus between the screen and the borehole was backfilled with a 60/40 grade Ottawa sand.

A cement/bentonite slurry grout (10:1 ratio by weight cement to bentonite) was used to backfill the borehole from the top of the filter sand to the ground surface. The grout was injected with a tremie pipe to minimize disturbance of the filter

sand. In cases where the top of the screen was less than fifteen feet from ground surface, bentonite pellets were used to seal the well instead of the slurry grout. Typical monitoring well construction is depicted in Figure 3-3.

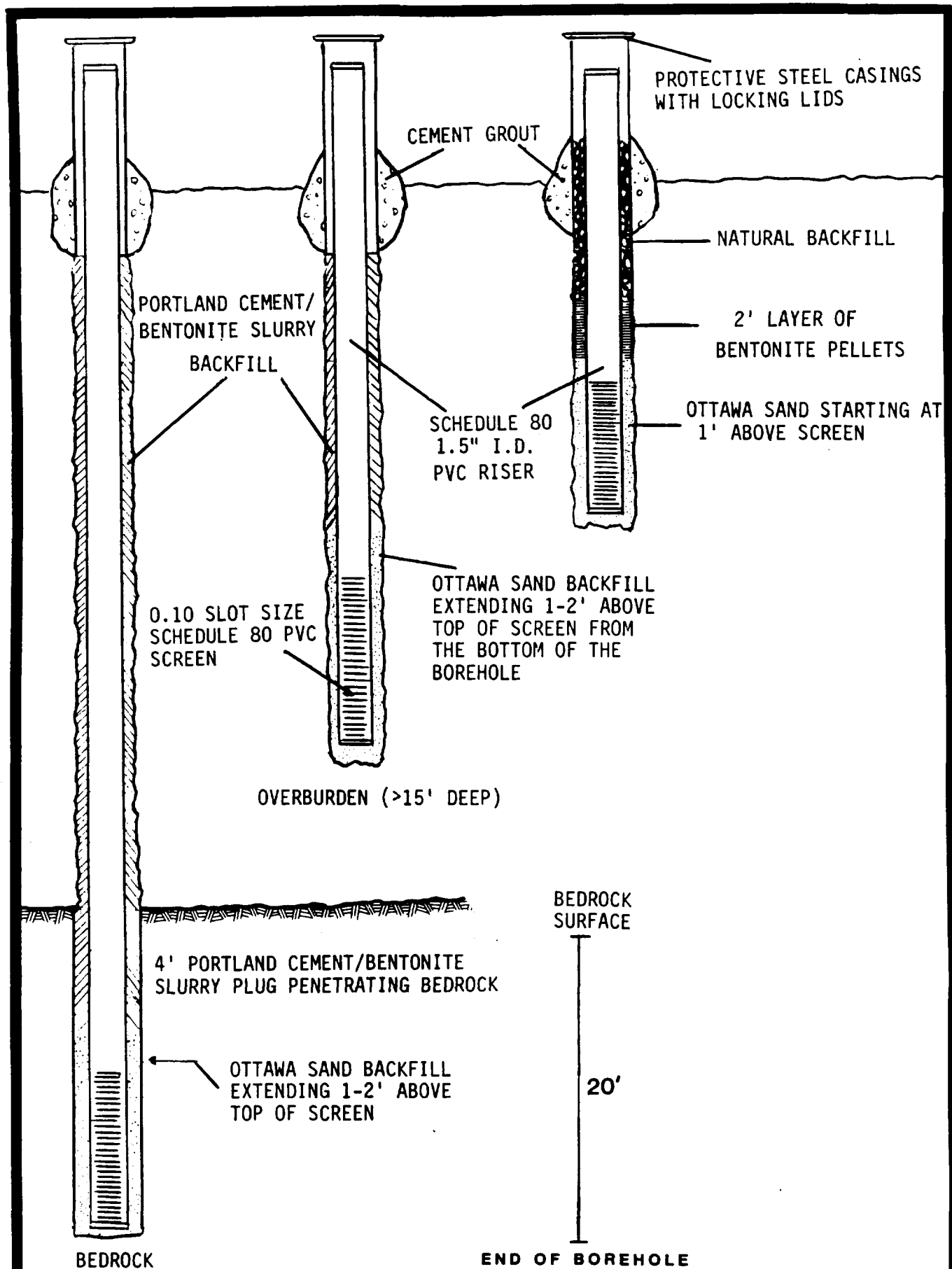
One well from each nested location was cored twenty feet into the bedrock using an NWX size diamond core bit according to standard ASTM method for diamond core drilling. All rock cores were examined in the field, and boxed, labelled and retained by NUS/FIT for future reference. Rock quality designations (RQDs) were calculated for each five foot coring run and are presented in Chapter 4 of this report. Bedrock wells were screened with fifteen feet of 0.010 inch slotted 1.5 inch slotted inside diameter PVC.

Filter sand was added to a level approximately one foot above the top of screen. Cement/bentonite slurry was then emplaced via a tremie pipe with the grout being brought to ground surface. In this manner, a four foot grout plug was emplaced into the bedrock limiting or precluding groundwater movement in the borehole penetrating the overburden and bedrock aquifers.

The PVC risers extended to a level approximately 2.5 feet above ground surface (except on UniFirst Corporation property, where limited space demanded subsurface installation). A five foot high steel security casing with lockable lid was placed around the riser. The security casing was cemented into the ground to a depth of 2.5 feet and locks were attached. Serial numbers engraved on each lock were removed by filing.

3.3 In-Situ Permeability Testing/Grain Size Analysis

The objective of conducting in-situ (field) permeability testing and collecting overburden samples for grain size analysis was to provide quantitative data on hydraulic conductivity of the major surficial units through which groundwater (and contamination) is migrating within the study area.



In-situ falling head permeability tests were conducted. A total of sixteen tests were run at seven locations in two or three strata characteristic of the stratigraphic column. The falling head tests were conducted through an Ottawa sand or coarse gravel "pack" with a particle size visibly larger than the particle size of the stratum being tested (so that the "pack" would not be the limiting factor). Water was added to the top of the casing and measurements were then taken at pre-determined time intervals while the water level in the casing dropped. Duration varied from test to test. Laboratory grain size analysis was conducted on 49 samples collected from strata of interest to provide confirmation of visual classification. Particle size distribution curves were developed from a combined sieve and hydrometer analysis. Results of both the in-situ permeability test and grain size analysis including curves and calculations are presented in Appendix F.

3.4 Base Map Development

NUS/FIT began base map development by acquiring the latest existing topographic map of the area which was drafted by Lockwood, Kessler & Bartlett for the City of Woburn in 1966. NUS/FIT, through EPA, acquired aerial photographic imagery taken in April, 1985. The topographic base map and new aerial imagery were forwarded to EPA's Environmental Photographic Interpretation Center (EPIC), where the planimetric features were transposed from the aerial imagery to a mylar overlay. The overlay was returned to NUS, where a new basemap was created incorporating current (1985) cultural and topographic features. The basemap was subsequently submitted to the United States Geological Survey (USGS) for review where it was further refined. This combined effort produced a base map which reflects the current land use within the study area and is presented as Plate 1 of this report.

3.5 Surveying of Well Locations

In November, 1985, NUS/FIT contracted for ground surveying to accurately locate and establish elevations of wells and piezometers where this data was lacking. All

elevations and distances were established from existing bench marks. Post-survey calculations conducted by NUS/FIT substantiate that the subcontractor stayed well within the permissible closure limits.

Vertical and horizontal data for a number of wells along the eastern flank of the study were made available by EPA through another consultant working in the area. Verification of a number of these points was conducted during the NUS/FIT surveying task and found to be accurate. In total, 100 points were located and elevations established, including the elevation of the Aberjona River.

3.6 Final Sampling Rounds

Groundwater and surface water samples were collected to provide:

- characterization of groundwater and surface water quality as it relates to drinking water standards.
- horizontal and vertical extent of groundwater contamination
- the chemical nature of groundwater contamination
- data to determine source areas of groundwater contamination

NUS/FIT conducted three Contract Laboratory Program (CLP) analysis sampling rounds during the investigation with one round completed each month for the months of April, May, and June, 1985. Study area sampling locations are depicted on Plate 2. Sampling locations north of the study area (north of Mishawum Road) are depicted on Figure 3-1B.

The techniques used by NUS/FIT for well purging and water sample collection are presented in Appendix D.

During the month of April, 1985, 143 samples were collected for a variety of analyses. These numbers include 103 monitoring well locations and 6 surface water locations. Six of the samples collected were screened in-house by NUS/FIT, with the remainder sent to laboratories under the CLP for volatile organic, extractable organic, metal, and drinking water quality standards (Table 3-3).

During the month of May, 1985, NUS/FIT collected a total of 92 samples including 67 monitoring well locations and 6 surface water locations. Fifteen of these samples were analyzed for CLP Hazardous Substance List (HSL) organic compounds and metals. Seventy-seven samples were analyzed for the presence of volatile organic contaminants through the CLP (Table 3-4).

The third and final sampling round was conducted in June, 1985 with a total of 126 samples collected from 78 monitoring well locations and 6 surface water locations. All samples from this round were submitted to CLP for analysis, including 88 samples for volatile organic analysis, 18 samples for HSL organics and metals analysis, and 20 samples for federal and state drinking water quality standards (Table 3-5). Aqueous samples collected for inorganic analysis were filtered to provide data on dissolved constituents. Dissolved concentrations of inorganic parameters will provide data on drinking water quality in support of the Feasibility Study. Table 3-6 summarizes all CLP analyses and shipments. Table 3-7 lists the federal and state drinking water quality parameters. Appendix D provides an explanation of analytical procedures used in this study. Appendix G provides a summary of analytical results which will be discussed in Section 5.0.

3.7 Water Level Measurements

NUS/FIT personnel measured water levels in monitoring wells within the Wells G & H study area from April 2-4, 1985. The water level measurements collected from all monitoring wells were used to construct the water table contour map depicted as Plate 4.

TABLE 3-3
NUS/FIT APRIL 1985 SAMPLING ROUND COLLECTION SUMMARY

<u>Sample Location</u>	<u>Sample Number</u>	<u>Traffic Report No.</u>	<u>Date Sampled</u>	<u>Time Sampled (hrs)</u>	<u>Total Vol. Purged (gal)</u>	<u>Sample pH</u>	<u>Analysis</u>
S-4	12406	AB369	4/16/85	1357			
S-5	12392	AB353	4/16/85	0824	23	-	VOA
S-6	12393	AB358	4/16/85	0839	50	-	VOA
S-10	12408	AB371	4/16/85	1528	26	-	VOA
S-11	12399	AB363	4/16/85	1111	11.5	-	VOA
S-21	12387	AB348	4/16/85	1030	23.5	-	VOA
S-22	12481	AB513	4/11/85	0955	6	6.4	VOA
S-41	12487	AB517	4/24/85	1355	10.5	-	VOA/SAS
S-46	12430	AB382	4/18/85	1301	-	-	VOA
S-46 (dup)	12431	AB383	4/18/85	1301	-	-	VOA
S-47	12429	-	4/18/85	1249	-	-	VOA
S-63D	12494	AB504	4/23/85	1415	12.8	-	In-house
S-63S	12493	AB503	4/23/85	1430	12.9	-	VOA
S64D	12377	AB338	4/10/85	1037	5.5	8.6	VOA
S64D (dup)	12378	AB339	4/10/85	1037	5.5	8.6	VOA
S64M	12380	AB341	4/10/85	1128	6.1	8.5	VOA
S64M (dup)	12381	AB342	4/10/85	1128	6.1	8.5	VOA
S64S	12376	AB337	4/10/85	1026	5.6	7.8	VOA
S65D	12365	AB327	4/09/85	0906	24.5	7.0	VOA
S65M	12366	AB328	4/09/85	0924	24.9	6.4	VOA
S65S	12367	AB329	4/19/85	0932	24	6.2	VOA
S66D	12407	AB370	4/16/85	1442	16.1	6.6	VOA
S67D	12386	AB347	4/11/85	0945	19.6	6.6	VOA
S67M	12385	AB346	4/11/85	0930	16.5	6.3	VOA
S67S	12384	AB345	4/11/85	0910	16.5	5.9	VOA
S68D	12478	AB542/MAA220	4/23/85	1605	-	-	HSL/metals/SAS
S68D (dup)	13082	-	4/23/85	1605	-	-	SAS
S68M	12477	AB533/MAA219	4/23/85	1620	-	-	HSL/metals/SAS
S69D	12364	AB326	4/09/85	0847	19.7	6.0	VOA
S-70M	12371	AB333	4/09/85	1117	13.7	6.6	VOA
S-70S	12370	AB332	4/09/85	1105	13.4	7.2	VOA
S-71D	12433	AB534/MAA216	4/22/85	1101	15.0	-	HSL/metals
S71M	12432	AB505	4/22/85	1050	dry	-	VOA
S72D	12395	AB360	4/16/85	0906	60.0	11.2	VOA
S72M	12396	AB384	4/16/85	0928	39.0	9.8	HSL
S72S	12394	AB359	4/16/85	0851	21.0	9.7	VOA
S73D	12473	AB510	4/23/85	1051	27.5	-	VOA/SAS
S73S	12474	AB511	4/23/85	1123	15.0	-	VOA/SAS
S74D	12476	AB512	4/23/85	1444	46.0	-	VOA/SAS
S74M	12475	AB536/MAA218	4/23/85	1401	25.0	-	HSL/metals/SAS
S75D	12390	AB351	4/11/85	1300	37.5	6.6	VOA
S75M	12389	AB350	4/11/85	1125	30.0	6.4	VOA
S75S	12388	AB349	4/11/85	1110	16.5	6.3	VOA
S77D	12427	AB381	4/11/85	1121	62.5	9.5	VOA
S77M	12400	AB385	4/16/85	1227	34.0	8.0	HSL
S77S	12401	AB364	4/16/85	1252	12.5	8.2	VOA
S77SS	12402	AB365	4/16/85	1259	5.5	8.5	VOA

TABLE 3-3
NUS/FIT APRIL 1985 SAMPLING ROUND COLLECTION SUMMARY
PAGE TWO

<u>Sample Location</u>	<u>Sample Number</u>	<u>Traffic Report No.</u>	<u>Date Sampled</u>	<u>Time Sampled (hrs)</u>	<u>Total Vol. Purged (gal)</u>	<u>Sample pH</u>	<u>Analysis</u>
S78D	12404	AB367	4/16/85	1332	31.0	8.3	VOA
S78D (dup)	12405	AB368	4/16/85	1332	31.0	8.3	VOA
S78S	12416	AB389	4/16/85	1332	32.0	8.2	HSL
S79D	12360	AB322/MAA215	4/18/85	0905	10.0	8.8	HSL/metals
S80M	12357	AB319/MAA212	4/08/85	1125	30.0	6.4	HSL/metals
S80M (dup)	12358	AB320/MAA213	4/08/85	1125	30.0	6.4	HSL/metals
S80S	12359	AB321/MAA214	4/08/85	1147	30.0	6.2	HSL/metals
S81D	12368	AB330	4/09/85	1010	36.0	7.0	VOA
S81M	12369	AB331	4/19/85	1041	21.0	10.5	VOA
S81S	12411	AB395	4/17/85	1050	4.5	-	HSL
S81S (dup)	12412	AB388	4/17/85	1050	4.5	-	HSL
S82	12397	AB340	4/10/85	1113	15.0	8.3	VOA
S83	12479	AB538/MAA221	4/23/85	1553	37.0	-	HSL/metals
S83 (dup)	12480	AB539/MAA222	4/23/85	1553	37.0	-	HSL/metals
S84D	12437	AB507	4/23/85	0858	35.0	-	VOA
S84M	12471	AB508	4/23/85	0935	21.3	-	VOA
S84S	12472	AB509	4/23/85	0958	7.8	-	VOA
S85M	12398	AB362	4/16/85	1049	32.0	8.6	VOA
S85S	12397	AB361	4/16/85	1040	12.0	8.6	VOA
S86M	12409	AB386	4/16/85	0827	12.5	9.2	HSL
S86S	12410	AB387	4/16/85	1125	30.0	8.2	HSL
IUS-2A	12375	AB336	4/9/85	1549	70	5.4	VOA
IUS-2B	12373	AB335	4/9/85	1507	40	4.8	VOA
IUS-2B (dup)	12374	-	4/9/85	1507	40	4.8	In-house
IUS-2C	12372	AB334	4/9/85	1309	13	4.2	VOA
GW-3DB	12455	AB535/MAA227	4/24/85	1310	34	8.3	HSL/metals
GW-3D	12454	AB532/MAA226	4/24/85	1250	30	8.3	HSL/metals
GW-3S	12453	AB531/MAA225	4/24/85	1230	12	8.6	HSL/metals
GW-4S	12441	AB519	4/22/85	1450	10.5	10.3	VOA
GW-4D	12443	AB520	4/22/85	1655	10	13.3	VOA
GW-6	12444	-	4/22/85	1800	15	13.3	In-house
GW-7S	12439	AB525	4/22/85	1225	4.0	6.8	VOA
GW-7D	12440	AB526	4/22/85	1310	33	7.6	VOA
GW-9	12438	AB527	4/22/85	1120	6.5	8.3	VOA
GW-10S	12442	-	4/22/85	1630	12.5	12.3	In-house
GW-10D	12445	-	4/22/85	1830	18	13.5	In-house
GW-10DB	12446	-	4/23/85	0905	27.5	13.1	In-house
GW-11S	12447	AB521	4/23/85	0945	3.4	12.6	VOA
GW-11D	12450	AB522	4/23/85	1305	11	13.5	VOA
GW-12S	12448	AB523	4/23/85	1040	4.7	-	VOA
GW-12D	12449	AB524	4/23/85	1150	11.4	-	VOA
GO-1S	12456	AB528/MAA228	4/24/85	1810	6.0	8.2	HSL/metals
GO-1D	12457	AB529/MAA229	4/24/85	1830	12.0	8.3	HSL/metals
GO-1DB	12458	AB530/MAA230	4/24/85	1900	26.0	9.1	HSL/metals

TABLE 3-3
NUS/FIT APRIL 1985 SAMPLING ROUND COLLECTION SUMMARY
PAGE THREE

<u>Sample Location</u>	<u>Sample Number</u>	<u>Traffic Report No.</u>	<u>Date Sampled</u>	<u>Time Sampled (hrs)</u>	<u>Total Vol. Purged (gal)</u>	<u>Sample pH</u>	<u>Analysis</u>
BW-1	12417	AB374	4/18/85	0934	33.5	-	VOA
BSW-1	12428	AB393	4/18/85	1223	25	-	HSL
BW-2	12425	AB380	4/18/85	1029	37.5	-	VOA
BSW-2	12424	AB379	4/18/85	1011	14.5	-	VOA
BW-3	12413	AB372	4/17/85	1148	27	-	VOA
BW-4	12423	AB378	4/18/85	1005	35	-	VOA
BW-5	12426	AB391	4/18/85	1149	28	-	HSL
BSW-6	12419	AB375	4/18/85	0942	17.5	-	VOA
BSW-6 (dup)	12420	AB376	4/1/885	0942	17.5	-	VOA
BSSW-6	12418	AB392	4/18/85	0925	10.5	-	HSL
BW-7	12422	AB377	4/18/85	1040	10	-	VOA
BSW-7	12421	AB390	4/18/85	1020	30	-	HSL
OW-7	12489	AB492	4/24/85	0900	80	-	VOA/SAS
OW-8	12490	AB493	4/24/85	1000	500	-	VOA/SAS
OW-19	12207	AB400	4/23/85	1515	500	-	VOA/SAS
OW-19A	12206	AB399	4/23/85	1345	130	-	VOA/SAS
OW-20	12397	AB397	4/23/85	1130	320	-	VOA/SAS
OW-20A	12205	AB398	4/23/85	1214	110	-	VOA/SAS
SW-01	12361	AB323	4/08/85	1330	-	-	VOA
SW-02	12362	AB324	4/08/85	1338	-	-	VOA
SW-02 (dup)	12363	AB325	4/08/85	1340	-	-	VOA
SW-03	12482	AB514	4/24/85	1038	-	-	VOA
Sw-03 (dup)	12483	AB515	4/24/85	1038	-	-	VOA
SW-04	12484	AB540/MAA223	4/24/85	1118	-	-	HSL/metals
SW-05	12485	AB516	4/24/85	1209	-	-	VOA
SW-06	12486	AB541/MAA224	4/24/85	1222	-	-	HSL/metals
Test Well 4C	12491	AB501	4/24/85	1100	30	-	VOA
Test Well 2C	12492	AB502	4/24/85	1215	50	-	VOA
Blank	12382	AB343	-	-	-	-	VOA
Blank	12383	AB344	-	-	-	-	VOA
Blank	12391	AB352	-	-	-	-	VOA
Blank	12403	AB366	-	-	-	-	VOA
Blank	12414	AB373	-	-	-	-	VOA
Blank	12415	AB394	-	-	-	-	HSL
Blank	12434	AB506	-	-	-	-	VOA
Blank	12435	-	-	-	-	-	SAS
Blank	12436	AB537/MAA217	-	-	-	-	HSL/metals
Blank	12209	AB518	-	-	-	-	VOA
Blank	12356	AB318/MAA211	-	-	-	-	HSL/metals

TABLE 3-3
NUS/FIT APRIL 1985 SAMPLING ROUND COLLECTION SUMMARY
PAGE FOUR

<u>Summary</u>	<u>Volatiles</u>	<u>HSL</u>	<u>HSL + Metals</u>	<u>SAS</u>
Monitoring Well Location	72	10	14	13
Surface Water Locations	4	-	2	-
Duplicates: Groundwater	5	1	2	1
Surface water	2	-	-	-
Blanks	7	1	2	1
Total	<u>90</u>	<u>12</u>	<u>20</u>	<u>15</u>

LEGEND:

- - no data for that category
- HSL - Hazardous Substance List organics which includes volatiles, base/neutral and acid extractables, pesticides, and PCBs.
- VOA - Hazardous Substance List volatile organics
- SAS - Federal & State Drinking Water Quality Standards
- In-house - NUS/FIT volatile organic screening analysis
- Metals - Hazardous Substance List inorganic constituents

Groundwater sample collection locations are designated by well number.

Surface water sample collection locations are designated by SW prefix.

**TABLE 3-4
NUS/FIT MAY 1985 SAMPLING ROUND COLLECTION SUMMARY**

<u>Sample Location</u>	<u>Sample Number</u>	<u>Traffic Report No.</u>	<u>Date Sampled</u>	<u>Time Sampled (hrs)</u>	<u>Total Vol. Purged (gal)</u>	<u>Sample pH</u>	<u>Analysis</u>
S-5	12765	AB822	5/21/85	0855	26.2	-	VOA
S-6	12766	AB821	5/21/85	0911	40.0	4.8	VOA
S-6 (dup)	12767	AB820	5/21/85	0911	40.0	4.8	VOA
S-21	12806	AB916	5/30/85	0850	6.5	-	VOA
S-22	12805	AB915	5/30/85	0818	6.0	-	VOA
S-44	12802	AB913	5/29/85	1350	-	-	VOA
S63D	12774	AB813	5/21/85	1131	11.0	5.7	VOA
S63S	12775	AB812	5/21/85	1145	4.0	4.9	VOA
S64D	12736	AB709/MAA412	5/14/85	0939	25.0	-	HSL/metal
S64M	12735	AB708/MAA411	5/14/85	0950	15.0	-	HSL/metal
S64M (dup)	12737	AB710/MAA413	5/14/85	1000	15.0	-	HSL/metal
S64S	12734	AB707/MAA410	5/14/85	1020	6.0	-	HSL/metal
S65D	12750	AB727	5/16/85	0920	18.0	-	VOA
S65M	12749	AB726	5/16/85	0935	8.0	-	VOA
S65M (dup)	12751	AB728	5/16/85	0935	8.0	-	VOA
S65S	12748	AB725	5/16/85	0911	2.0	-	VOA
S66D	12781	AB806	5/22/85	1037	8.25	5.9	VOA
S67D	12780	AB807	5/22/85	1055	26.4	6.6	VOA
S67M	12778	AB809	5/22/85	0826	12.5	7.0	VOA
S67S	12779	AB808	5/22/85	0957	dry at 4.0	5.9	VOA
S68D	12754	AB731	5/16/85	1100	51.0	6.8	VOA
S68D (dup)	12755	AB732	5/16/85	1105	51.0	6.8	VOA
S68M	12753	AB730	5/16/85	1019	20.0	5.4	VOA
S70M	12759	AB828	5/21/85	1040	21.4	7.9	VOA
S70S	12758	AB829	5/21/85	1005	7.3	6.6	VOA
S71D	12761	AB826	5/21/85	1315	14.5	8.3	VOA
S71M	12760	AB827	5/21/85	1300	bailed dry	11.2	VOA
S72D	12776	AB811	5/21/85	1514	60.0	-	VOA
S72D (dup)	12777	AB810	5/21/85	1514	60.0	-	VOA
S72M	12772	AB815	5/21/85	1046	40.5	-	VOA
S72S	12773	AB814	5/21/85	1055	21.6	-	VOA
S73D	12768	AB819	5/21/85	0940	25.4	-	VOA
S73S	12769	AB818	5/21/85	0953	12.7	-	VOA
S74D	12771	AB816	5/21/85	1010	dry at 8.0	5.6	VOA
S74M	12770	AB817	5/21/85	1021	29.0	-	VOA
S75D	12785	AB802	5/22/85	1450	38.5	6.1	VOA
S75M	12783	AB805	5/22/85	1139	30.0	5.3	VOA
S75M (dup)	12784	AB803	5/22/85	1139	30.0	5.3	VOA
S75S	12782	AB804	5/22/85	1120	15.4	5.5	VOA
S76D	12786	AB899	5/29/85	1310	20.0	-	VOA
S76M	12787	AB897	5/29/85	1255	60.0	-	VOA
S76M (dup)	12788	AB898	5/29/85	1255	60.0	-	VOA
S76S	12789	AB896	5/29/85	1245	3.0	-	VOA
S77D	12804	AB900	5/29/85	1600	70.0	-	VOA
S77M	12799	AB910	5/29/85	1106	40.0	6.4	VOA

TABLE 3-4
NUS/FIT MAY 1985 SAMPLING ROUND COLLECTION SUMMARY
PAGE TWO

<u>Sample Location</u>	<u>Sample Number</u>	<u>Traffic Report No.</u>	<u>Date Sampled</u>	<u>Time Sampled (hrs)</u>	<u>Total Vol. Purged (gal)</u>	<u>Sample pH</u>	<u>Analysis</u>
S77M (dup)	12800	AB911	5/29/85	1106	40.0	6.4	VOA
S77S	12798	AB909	5/29/85	1050	15.0	6.1	VOA
S77SS	12797	AB908	5/29/85	1040	10.0	5.9	VOA
S78D	12803	AB914	5/29/85	1536	35.0	7.9	VOA
S78S	12801	AB912	5/29/85	1240	10.9	5.6	VOA
S79D	12793	AB904	5/29/85	0940	61.0	7.5	VOA
S79M	12794	AB905	5/29/85	0926	50.0	5.9	VOA
S80M	12795	AB906	5/29/85	1019	30.0	5.8	VOA
S80S	12796	AB907	5/29/85	1002	34.0	5.4	VOA
S81D	12744	AB714/MAA402	5/14/85	1520	20.0	-	HSL/metals
S81M	12745	AB713/MAA401	5/14/85	1507	35.0	-	HSL/metals
S81S	12746	AB723	5/14/85	1605	8.0	-	VOA
S82	12730	AB715	5/14/85	0850	15.0	-	VOA
S82 (dup)	12731	AB716	5/14/85	0850	15.0	-	VOA
S83	12814	AB924	5/30/85	1205	35.0	-	VOA
S84D	12743	AB722	5/14/85	1422	35.0	-	VOA
S84M	12742	AB721	5/14/85	1410	20.0	-	VOA
S84S	12741	AB720	5/14/85	1400	10.0	-	VOA
S85M	12739	AB712/MAA415	5/14/85	1106	40.0	-	HSL/metals
S85S	12738	AB711/MAA414	5/14/85	1127	20.0	-	HSL/metals
S86M	12757	AB734	5/16/85	1324	dry at 15.0	-	VOA
S86S	12752	AB729	5/16/85	0958		5.4	VOA
GO-1S	12727	AB703/MAA406	5/15/85	1045	6.0	5.7	HSL/metals
GO-1D	12729	AB705/MAA408	5/15/85	1150	11.0	5.9	HSL/metals
GO-1DB	12728	AB704/MAA407	5/15/85	1130	25.0	5.9	HSL/metals
GW-3S	12724	AB396/MAA403	5/15/85	0825	12.0	6.2	HSL/metals
GW-3D	12725	AB701/MAA404	5/15/85	0910	30.0	7.2	HSL/metals
GW-3DB	12726	AB702/MAA405	5/15/85	0945	32.5	7.1	HSL/metals
Test Well 2A	12756	AB733	5/16/85	1330	45.0	-	VOA
Test Well 2C	12740	AB719	5/14/85	1330	42.0	-	VOA
Test Well 4B	12747	AB724	5/16/85	0819	32.5	4.9	VOA
SW-01	12807	AB917	5/30/85	0906	-	-	VOA
SW-02	12808	AB918	5/30/85	0923	-	-	VOA
SW-03	12809	AB919	5/30/85	0940	-	-	VOA
SW-03 (dup)	12810	AB920	5/30/85	0940	-	-	VOA
SW-04	12811	AB921	5/30/85	1005	-	-	VOA
SW-05	12812	AB922	5/30/85	1020	-	-	VOA
SW-06	12813	AB923	5/30/85	1034	-	-	VOA
Blank	12790	AB901	-	-	-	-	VOA
Blank	12791	AB902	-	-	-	-	VOA
Blank	12792	AB903	-	-	-	-	VOA
Blank	12762	AB825	-	-	-	-	VOA
Blank	12763	AB824	-	-	-	-	VOA
Blank	12764	AB823	-	-	-	-	VOA
Blank	12723	AB706/MAA409	-	-	-	-	HSL/metals
Blank	12732	AB717	-	-	-	-	VOA
Blank	12733	AB718	-	-	-	-	VOA

TABLE 3-4
NUS/FIT MAY 1985 SAMPLING ROUND COLLECTION SUMMARY
PAGE THREE

<u>Summary</u>	<u>Volatiles</u>	<u>HSL + Metals</u>
Monitoring Well Locations	54	13
Surface Water Locations	6	-
Duplicates: Groundwater	8	1
Surface Water	1	-
Blanks	8	1
Total	<u>77</u>	<u>15</u>

LEGEND

- - no data for that category

HSL - Hazardous Substance List organics which includes volatiles, base/neutral and acid extractables, pesticides, and PCBs.

VOA - Hazardous Substance List volatile organics

Metals - Hazardous Substance List inorganic constituents.

Groundwater sample collection locations are designated by well number.

Surface water sample collection locations are designated with an SW prefix.

TABLE 3-5
NUS/FIT JUNE 1985 SAMPLING ROUND COLLECTION SUMMARY

<u>Sample Location</u>	<u>Sample Number</u>	<u>Traffic Report No.</u>	<u>Date Sampled</u>	<u>Time Sampled (hrs)</u>	<u>Total Vol. Purged (gal)</u>	<u>Sample pH</u>	<u>Analysis</u>
S-4	13273	AC233	6/19/85	1030	35	-	VOA
S-5	13254	AC228	6/17/85	1410	44	6.0	VOA
S-6	13246	AB957	6/12/85	1425	35	6.4	VOA
S-10	13257	AC231	6/17/85	1310	13.5	7.2	VOA
S-11	13256	AC230	6/18/85	1500	33	-	VOA
S-44	13258	AC232	6/17/85	1335	-	-	VOA
S63D	13239	AB950	6/12/85	0900	10	-	VOA
S63S	13238	AB949	6/12/85	0845	4	5.7	VOA
S64D	13207	AC462/MAA663	6/28/85	1000	27.5	-	HSL/metals
S64M	13294	AC430/MAA644	6/25/85	1000	11.8	7.4	VOA/SAS
S64M (dup)	13296	AC434	6/25/85	1000	11.8	7.4	VOA
S64S	13184	AC425/MAA643	6/25/85	1030	7.1	6.6	VOA/SAS
S64S (dup)	13186	AC440	6/25/85	1030	7.1	6.6	VOA
S65D	13226	AB937	6/10/85	1310	16.5	7.4	VOA
S65M	13232	AB943	6/11/85	1315	7	6.8	VOA
S65S	13233	AB944	6/11/85	1245	1	6.4	VOA
S66D	13234	AB945	6/11/85	1245	8.6	7.2	VOA
S67D	13235	AB946	6/11/85	1515	26	7.3	VOA
S67M	13237	AB948	6/11/85	1530	12.5	7.0	VOA
S67S	13236	AB947	6/11/85	1445	6.5	6.8	VOA
S68M	13187	AC452/MAA654	6/26/85	0900	46	7.5	HSL/metals/SAS
		MAA635					
S68S	13188	AC453/MAA655	6/26/85	0930	19	8.6	HSL/metals/SAS
		MAA636					
S70M	13290	AC438	6/24/85	1630	23	8.2	VOA
S70S	13291	AC439	6/24/85	1630	8	6.8	VOA
S71D	13289	AC445/MAA647	6/24/85	1415	15	7.5	HSL/metals
S71M	13292	AC436	6/24/85	1510	1.5	11.1	VOA
S72D	13185	AC424	6/25/85	1445	64.5	7.2	VOA
S72M	13299	AC427/MAA645	6/25/85	1215	43	5.9	VOA/SAS
S72S	13298	AC431/MAA646	6/25/85	1220	21	6.1	VOA/SAS
S73D	13230	AB941	6/11/85	1045	25	6.1	VOA
S73S	13229	AB940	6/11/85	1030	15	5.6	VOA
S75D	13231	AB942	6/11/85	1040	38.3	7.3	VOA
S75M	13228	AB939	6/11/85	0920	30	6.2	VOA
S75S	13227	AB938	6/11/85	0900,	15	6.3	VOA
S75S	13206	AC460/MAA662	6/27/85	1435	18	6.4	HSL/metals
S76D	13192	AC433/MAA639	6/26/85	1220	42	8.5	VOA/SAS
S76M	13191	AC442/MAA638	6/26/85	1215	52	6.8	VOA/SAS
S76S	13193	AC426/MAA637	6/26/85	1200	25	6.4	VOA/SAS
S77D	13288	AC429	6/25/85	0830	59	7.8	VOA
S77M	13255	AC229	6/18/85	1435	32.5	6.8	VOA
S77S	13204	AC458/MAA660	6/27/85	1400	15	6.7	HSL/metals
S77SS	13205	AC459/MAA661	6/27/85	1420	9	6.6	HSL/metals
S78D	13202	AC437	6/27/85	1120	34	6.4	VOA

TABLE 3-5
NUS/FIT JUNE 1985 SAMPLING ROUND COLLECTION SUMMARY
PAGE TWO

Sample Location	Sample Number	Traffic Report No.	Date Sampled	Time Sampled (hrs)	Total Vol. Purged (gal)	Sample pH	Analysis
S78S	13203	AC457/MAA659 MAA630	6/27/85	1100	12	-	HSL/metals/SAS
S81D	13190	AC461/MAA664	6/28/85	0845	35	-	HSL/metals
S81M	13297	AC447/MAA649 MAA640	6/25/85	0945	19.5	10.6	HSL/metals*/SAS
S81S	13194	AC449/MAA652 MAA631	6/26/85	1130	7.2	6.8	HSL/metals*/SAS
S82	13245	AB956	6/12/85	1055	12	7.3	VOA
S83	13222	AB933	6/10/85	1045	33	6.6	VOA
S83 (dup)	13223	AB934	6/10/85	1045	33	6.6	VOA
S84D	13182	AC443/MAA633	6/26/85	1210	34	6.4	VOA/SAS
S84M	13196	AC432/MAA627	6/27/85	0820	21	-	VOA/SAS
S84S	13197	AC435/MAA628	6/27/85	0830	9	-	VOA/SAS
S85M	13219	AB930	6/10/85	1010	32.5	6.6	VOA
S85M (dup)	13221	AB932	6/10/85	1010	32.5	6.6	VOA
S85S	13217	AB929	6/10/85	1000	12.5	5.6	VOA
S-86M	13225	AB936	6/10/85	1355	22.5	11.0	VOA
S-86S	13224	AB935	6/10/85	1330	12.5	6.7	VOA
S-81M (dup)	13287	AC448/MAA650 MAA641	6/25/85	0945	19.5	10.6	HSL/metals/SAS
S-81S (dup)	13195	AC450/MAA653 MAA632	6/26/85	1130	7.2	6.8	HSL/metals/SAS
S-85S (dup)	13220	AB931	6/10/85	1000	12.5	5.6	VOA
GW-3DB	13269	AC245	6/19/85	1025	33.5	7.4	VOA
GW-3D	13267	AC243	6/19/85	1005	32	6.8	VOA
GW-3S	13265	AC241	6/19/85	0955	12.2	6.4	VOA
GW-4S	13259	AC235	6/19/85	0805	10.8	6.6	VOA
GW-4D	13260	AC236	6/19/85	0825	2.5	7.2	VOA
GW-11S	13261	AC237	6/19/85	0840	3	7.0	VOA
GW-11D	13262	AC238	6/19/85	0900	3	7.0	VOA
GW-12S	13263	AC239	6/19/85	0925	5	6.6	VOA
GW-12D	12264	AC240	6/19/85	0935	11	6.4	VOA
GO-1S	13271	AC247	6/19/85	1130	0.08	6.9	VOA
GO-1DB	13272	AC248	6/19/85	1135	25	7.6	VOA
BW-1	13201	AC441/MAA629	6/27/85	1115	33	-	VOA/SAS
BSW-1	13251	AC225	6/17/85	0850	28	7.1	VOA
BW-2	13249	AC223	6/17/85	1015	32.5	6.0	VOA
BSW-2	13248	AC222	6/17/85	0930	14	5.5	VOA
BW-3	13200	AC456/MAA658	6/27/85	1345	36	6.8	HSL/metals
BW-4	13250	AC224	6/17/85	1115	13	6.3	VOA
BW-5	13253	AC227	6/17/85	1030	30	7.2	VOA
BSW-6	13247	AC221	6/17/85	1250	17.5	6.3	VOA
BSSW-6	13252	AC226	6/17/85	0930	11	7.1	VOA
BW-7	13199	AC455/MAA657	6/27/85	1030	39	6.2	HSL/metals
BSW-7	13198	AC454/MAA656	6/27/85	1015	12	6.2	HSL/metals

TABLE 3-5
NUS/FIT JUNE 1985 SAMPLING ROUND COLLECTION SUMMARY
PAGE THREE

<u>Sample Location</u>	<u>Sample Number</u>	<u>Traffic Report No.</u>	<u>Date Sampled</u>	<u>Time Sampled (hrs)</u>	<u>Total Vol. Purged (gal)</u>	<u>Sample pH</u>	<u>Analysis</u>
SW-01	13274	AC234	6/19/85	0925	-	-	VOA
SW-02	13275	AC249	6/19/85	0855	-	-	VOA
SW-03	13276	AC250	6/19/85	1100	-	-	VOA
SW-04	13277	AC251	6/19/85	0910	-	-	VOA
SW-05	13279	AC253	6/19/85	1045	-	-	VOA
SW-06	13280	AC254	6/19/85	0835	-	-	VOA
TW 2C	13241	AB952	6/12/85	1055	20	6.3	VOA
TW 4B	13240	AB951	6/12/85	1010	33	6.1	VOA
SW-04 (dup)	13278	AC252	6/19/85	0910	-	-	VOA
GW-3DB (dup)	13270	AC246	6/19/85	1025	33.5	7.4	VOA
GW-3D (dup)	13268	AC244	6/19/85	1005	32	6.8	VOA
GW-3S (dup)	13266	AC242	6/19/85	0955	12.2	6.4	VOA
Blank	13242	AB953	-	-	-	-	VOA
Blank	13243	AB954	-	-	-	-	VOA
Blank	13244	AB955	-	-	-	-	VOA
Blank	13281	AC255	-	-	-	-	VOA
Blank	13282	AC256	-	-	-	-	VOA
Blank	13283	AC257	-	-	-	-	VOA
Blank	13284	AC451	-	-	-	-	VOA
Blank	13293	AC444	-	-	-	-	VOA
Blank	13293	AC428	-	-	-	-	VOA
Blank	13295	AC451/MAA651	-	-	-	-	HSL/metals/SAS
Blank	13295	AC446/MAA648	-	-	-	-	HSL/metals/SAS

<u>Summary</u>	<u>Volatiles</u>	<u>HSL + Metals</u>	<u>SAS</u>
Monitoring Well Locations	64	14	16
Surface Water Locations	6	-	-
Duplicates: Groundwater	8	2	2
Surface Water	1	-	-
Blanks	9	2	2
Total	88	18	20

LEGEND:

- - no data for that category
- HSL - Hazardous Substance List organics which includes volatiles, base/neutral and acid extractables, pesticides, and PCBs.
- VOA - Hazardous Substance List volatile organics
- SAS - Federal & State Drinking Water Standards
- * - Inorganic results were identified as unusable because samples were not filtered.
- Metals - Hazardous Substance List inorganic constituents

TABLE 3-6
SUMMARY OF CONTRACT LABORATORY
ANALYSIS AND SHIPMENT
NUS/FIT APRIL, MAY AND JUNE 1985 SAMPLING ROUNDS

Month	Week	CLP Case No.	Number of Samples	Type of Analysis	Laboratory	Traffic Report Numbers
April	1	4158	5	HSL	ERCO	AB 318-322
			30	Volatiles	Aquatech	AB 323-352
	2	4179	5	Inorganics	CAA	MAA 211-215
			33	Volatiles	Aquatech	AB 379-400, 492-493, 501-527
			15	HSL	GCA	AB 528-542
May	3	4193	15	Inorganics	RMAL	MAA 216-230
			15	DWS	RMAL	not applicable
			15	DWS	Versar	not applicable
			27	Volatiles	Compuchem	AB 353, 358-383
			12	HSL	GCA	AB 384-395
	1	4344	15	HSL	CAA	AB 396, 701-714
			20	Volatiles	Aquatech	AB 715-734
	2	4395	15	Inorganics	Spectrix	MAA 401-415
			28	Volatiles	Aquatech	AB 802-829
			29	Volatiles	Compuchem	AB 896-924
June	3	4433	29	Volatiles	Compuchem	AB 929-957
	1	4514	29	Volatiles	GCA	AC 221-258
	2	4536	38	Volatiles	Envir	AC 424-444
	3	4574	21	Volatiles	GCA	AC 445-462
			18	HSL	US Test	MAA 647-650, 652-664
HSL	DWS		18	Inorganics	RMAL	MAA 627-646, 651
			20	DWS	LES	not applicable
	CLP		20	DWS		

HSL - Hazardous Substance List volatile organic and extractable organic compounds
DWS - Drinking Water Standards (State and Federal)
CLP - Contract Laboratory Program
Volatiles - Hazardous Substance List volatile organic compounds
Inorganics - Hazardous Substance List inorganic constituents

TABLE 3-7
FEDERAL AND STATE DRINKING WATER QUALITY STANDARDS

NATIONAL INTERIUM PRIMARY DRINKING WATER
REGULATIONS MAXIMUM CONTAMINANT LEVELS (MCLS)

Parameter

I. Inorganics

Primary Standards ⁽¹⁾

Maximum Contaminant Levels
for Inorganic Chemicals (mg/l)

Arsenic	0.05
Barium	1
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate as N	10.
Selenium	0.01
Silver	0.05
Fluoride	1.4 - 2.4 ⁽²⁾

II. Organic

a)	<u>Contaminant</u>	<u>Level (mg/l)</u>
	Endrin	0.0002
	Lindane	0.0004
	Methoxychlor	0.1
	Toxaphene	0.005
	2,4-D	0.1
	2,4,5-TP Silvex	0.01

b) Total Trihalomethanes (TTHM)

TTHM = sum of the organohalogen compounds

MCL = 0.10 mg/l

TABLE 3-7
FEDERAL AND STATE DRINKING WATER QUALITY STANDARDS
PAGE TWO

NATIONAL DRINKING WATER REGULATIONS
SECONDARY MAXIMUM CONTAMINANT LEVELS (SMCLS)

<u>Secondary Standards⁽³⁾</u>	<u>Recommended Maximum Contaminant Levels (mg/l)</u>
Chloride	250
Color	15 color units
Copper	1.0
Corrosivity ⁽⁴⁾⁽⁶⁾	non-corrosive
Iron	0.3
Manganese	0.05
Odor	3 threshold odor number
pH	6.5-8.5 s.u.
Sulfate	250
Zinc	5.0
Total Dissolved Solids	500
Foaming agents ⁽⁶⁾	0.5

OTHER:

Sodium 20 advisory level

Massachusetts Requirements

- Demand, such as COD, BOD⁽⁶⁾, TOC⁽⁶⁾, chlorine residual⁽⁶⁾.
- Pesticides, Herbicides, and other Organics, such as hydrocarbons, carbamates⁽⁶⁾ and organo-phosphorus compounds.
- Microbiological Analyses.
 - Total Coliform by the Membrane Filter Method.
 - Fecal Coliform by the Membrane Filter Method.
 - Total Coliform by the Fermentation Tube Method.
 - Fecal Coliform by the Fermentation Tube Method.
 - Standard Plate Count.

TABLE 3-7
FEDERAL AND STATE DRINKING WATER QUALITY STANDARDS
PAGE THREE

Maximum contaminant levels varies with the analytical technique. Number of samples taken is a function of population size.

- a) Membrane filter technique
The coliform bacteria count shall not exceed:
 - 1) 1/100 ml as the arithmetic mean of all samples examined per month; or
 - 2) 4/100 ml in more than one sample when 20 are examined per month; or
 - 3) 4/100 ml in more than 5% of samples when 20 or more are examined per month.
- b) Fermentation tube method and 10 ml standard portions. The coliform bacteria count shall not exceed:
 - 1) more than 10% of the portions in any month;
 - 2) three or more portions in more than one sample when less than 20 samples are examined per month; or
 - 3) three or more portions in more than 5% of the samples when 20 or more samples are examined per month.
- c) Fermentation tube method and 100 ml standard portions. The coliform bacteria count shall not exceed:
 - 1) more than 60% of the portions in any month.
 - 2) 5 portions in more than one sample when less than 5 samples are examined per month; or
 - 3) 5 portions in more than 20% of the samples when 5 or more samples are examined per month.

TABLE 3-7
FEDERAL AND STATE DRINKING WATER QUALITY STANDARDS
PAGE FOUR

● Additional Requirements

Chloroform -Trihalomethane formation potential⁽⁶⁾

Temperature

NOTES

- 1) 40 CFR Part 141 (Federal Register, Vol. 40, No. 248, December 24, 1975)
- 2) Maximum allowable concentration depends on annual average of maximum daily air temperature at site of supply.
- 3) 40 CFR Part 143 (Federal Register, Vol 44, No. 140, July 19, 1979).
- 4) Requires Calcium Hardness Alkalinity, TDS.
- 5) cuurently being constructed.
- 6) Analysis not performed due to unavailability of laboratories to perform test or inappropriateness of test as determined by EPA.

Selected monitoring wells were measured biweekly. The water level data from the selected monitoring wells served to establish a data base for US Geological Survey (USGS) groundwater modeling and aquifer test and will not be presented in this report.

Water level measurements were taken using a chalked tape water level indicator which was checked for accuracy against a standard steel measuring tape prior to its use in the field. A reference mark was placed on the PVC monitoring well riser as a continuing measuring reference point. The plunker and first six inches (or wetted portion) of measuring tape were decontaminated before use and between wells.

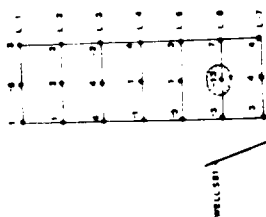
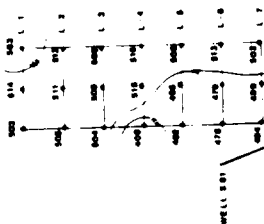
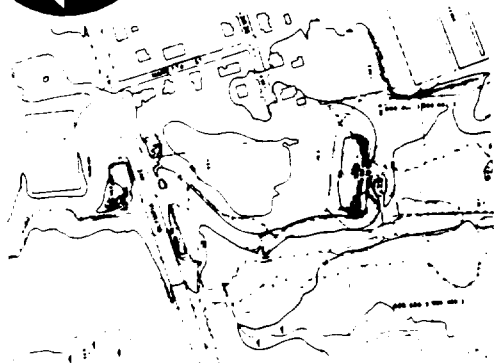
3.8 Magnetometry Survey

A potential disposal area based on a history of ground surface disturbance (excavation/re-working) exists in an area approximately 300' x 300' located to the south of Olympia Avenue and west of Dewey Street. A magnetometry survey was selected as an appropriate geophysical method for delineating buried metallic or ferrous objects in this area.

The magnetometer field survey was conducted by NUS/FIT staff using an EDA Instruments model PPM-500 proton precession magnetometer as a field magnetometer, and an EDA Instruments PPM-400 proton precession magnetometer as a magnetic base station. The area was tape surveyed to establish a twenty foot grid spacing. Figure 3-4 includes a map of the magnetometry survey area, as well as the total field and vertical gradient measurements. No significant anomalies were detected.

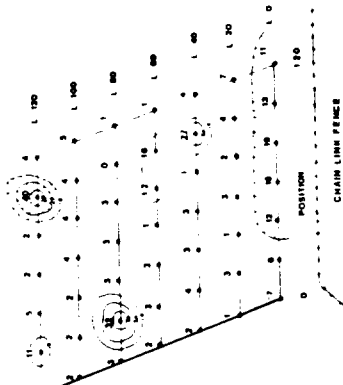
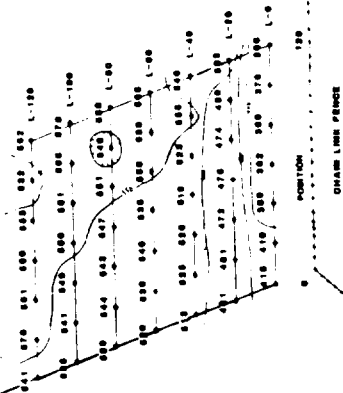
3.9 Aquifer Test

An initial draft screening of remedial strategies for Wells G & H has determined that one likely remedial option would be groundwater treatment (well head



TOTAL MAGNETIC FIELD (gammas)
(add 55,000 gammas for true value.)

MAGNETIC GRADIENT
(gammas)



MAGNETOMETER SURVEY
DATA CONTOURS
WELLS G&H SITE
WOBBURN, MA



SPRING 1985

FIGURE 3-4

treatment) and discharge. This option requires extensive data concerning aquifer characteristics such as concentration and spatial distribution for each contaminant of concern, as well as the physical and hydraulic properties of the aquifer. To address these data requirements, EPA opted for an extensive aquifer test beyond the original scope of this study.

EPA contracted the USGS to design an aquifer test that would provide data on the area of influence and zone of contribution of Wells G & H. Specifically, the test would demonstrate/determine:

- aquifer hydraulic conductivity
- aquifer specific yield
- the Wells G & H area of diversion
- the hydraulic relationship between the Aberjona River and Wells G & H

In support of this aquifer test, NUS/FIT personnel installed ten streambed piezometers along the Aberjona River. These piezometers were intended to provide data to aid in assessing the relationship between Aberjona River on the aquifer from which Wells G & H draw.

The USGS is expected to release the findings of the aquifer test at a later date.

4.0 HYDROGEOLOGIC INVESTIGATIONS

NUS/FIT conducted investigative tasks aimed at defining the geologic and hydrogeologic framework of the site in order to characterize contaminant migration mechanisms in soil and groundwater. Tasks were divided between Phase I and Phase II of the Remedial Investigation. During Phase I, NUS collected and evaluated the following data:

- Data collected by Ecology and Environment, Inc. (1980-1982)
- Analytical and hydrogeological data collected by W.R. Grace, Beatrice Foods and UniFirst Corporation in response to EPA administrative orders pursuant to RCRA Section 3013
- Data collected for the City of Woburn during exploratory testing to site Wells G & H
- Data collected by a variety of sources concerning groundwater and surface water south of Cedar/Salem Street, but within the hydrologic boundaries of the Aberjona aquifer (Ecology and Environment, Inc., 1982) (MWRC, 1967, 1973, 1975) (MDC, 1977, 1979)
- Data collected by a variety of sources concerning groundwater and surface water, north of State Route 128 (I-95), but within the hydrologic boundaries of the Aberjona aquifer (Roux Assoc., 1983a, 1983b, and 1984) (DEQE, 1977)
- Surface water quality data collected by DEQE within the study area (MDC, 1979)

Review of the existing data and preliminary data collected by NUS/FIT served to conceptualize the general hydrogeology of the Wells G & H aquifer area as well as indicate areas of contamination. These findings were further utilized in selecting initial locations for the drilling and installation of monitoring wells.

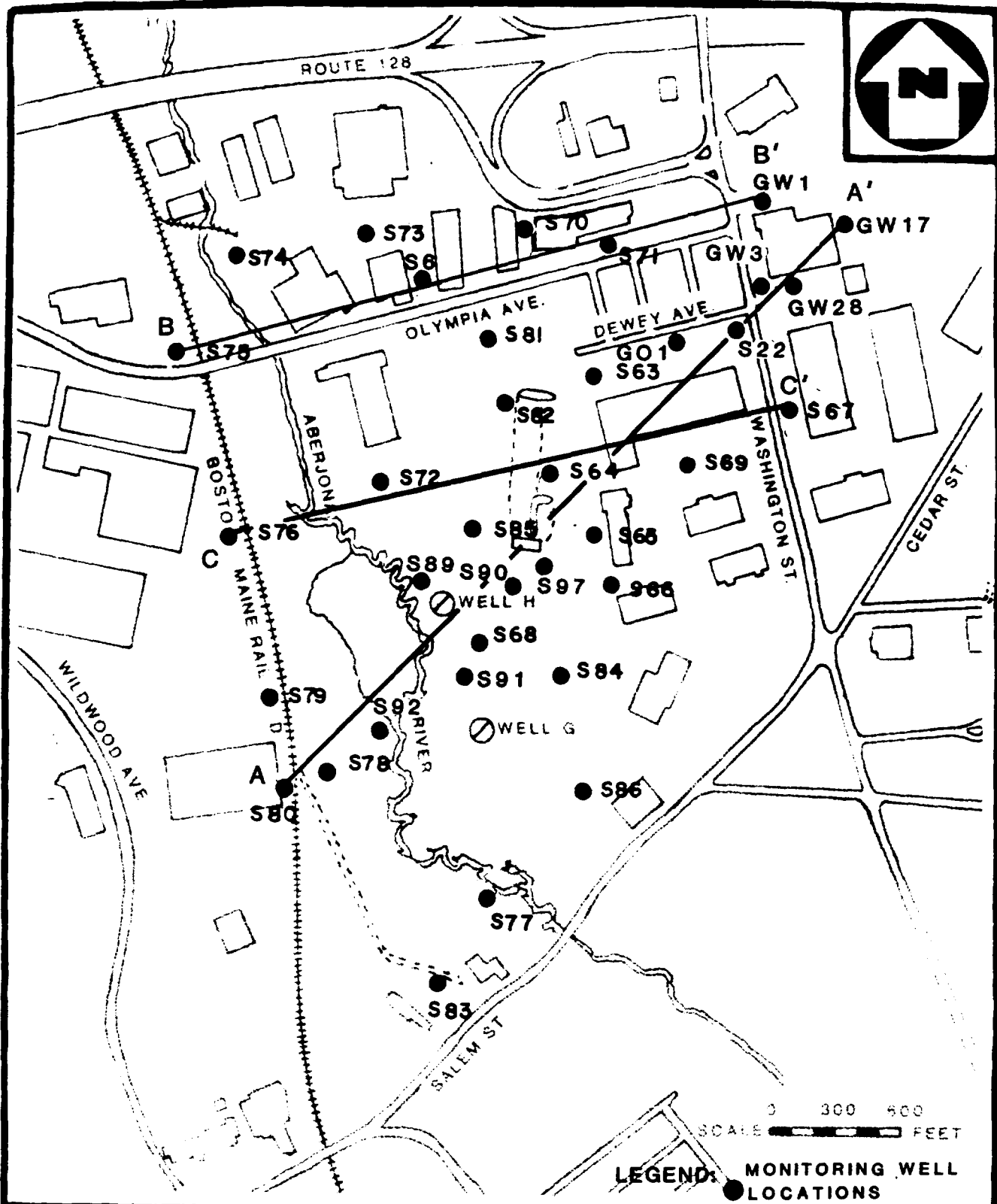
A greater understanding of site hydrogeology was developed using data collected during Phase II of the Remedial Investigation. Field investigation methods are described in Chapter 3. Further detail on method protocols is presented in Appendix D. Analysis of split spoon samples and of bedrock cores collected during monitoring well installations at 24 new locations enabled NUS/FIT to better characterize the type and extent of surficial deposits and bedrock formations that underlie the study area. Permeabilities of the various units encountered were calculated from data collected during 16 in-situ field permeability tests. Laboratory grain size analysis was conducted on 49 representative soil samples. The results of the in-situ field permeability tests and grain size analyses are presented in Appendix F.

Information gathered by other consulting firms was also included in the evaluation of the geology and hydrogeology of the area. Appendix B contains geologic data collected by consultants other than NUS/FIT.

The compiled data indicate that Wells G & H are located within a buried glacial valley. Figures 4-1 through 4-4 depict the generalized geology through geologic cross-sections.

The surficial geologic units of the study area are comprised primarily of glacial deposits consisting of a complex mixture of sand, silt, clay, and gravel. The majority of the sediments are the result of Late Wisconsin glaciation which receded through the Mystic River and Aberjona River Valleys approximately 14,000 years ago (Ecology and Environment, 1982b). Recent alluvial deposits associated with the Aberjona River overlie the glacial deposits at the lower elevations in the study area.

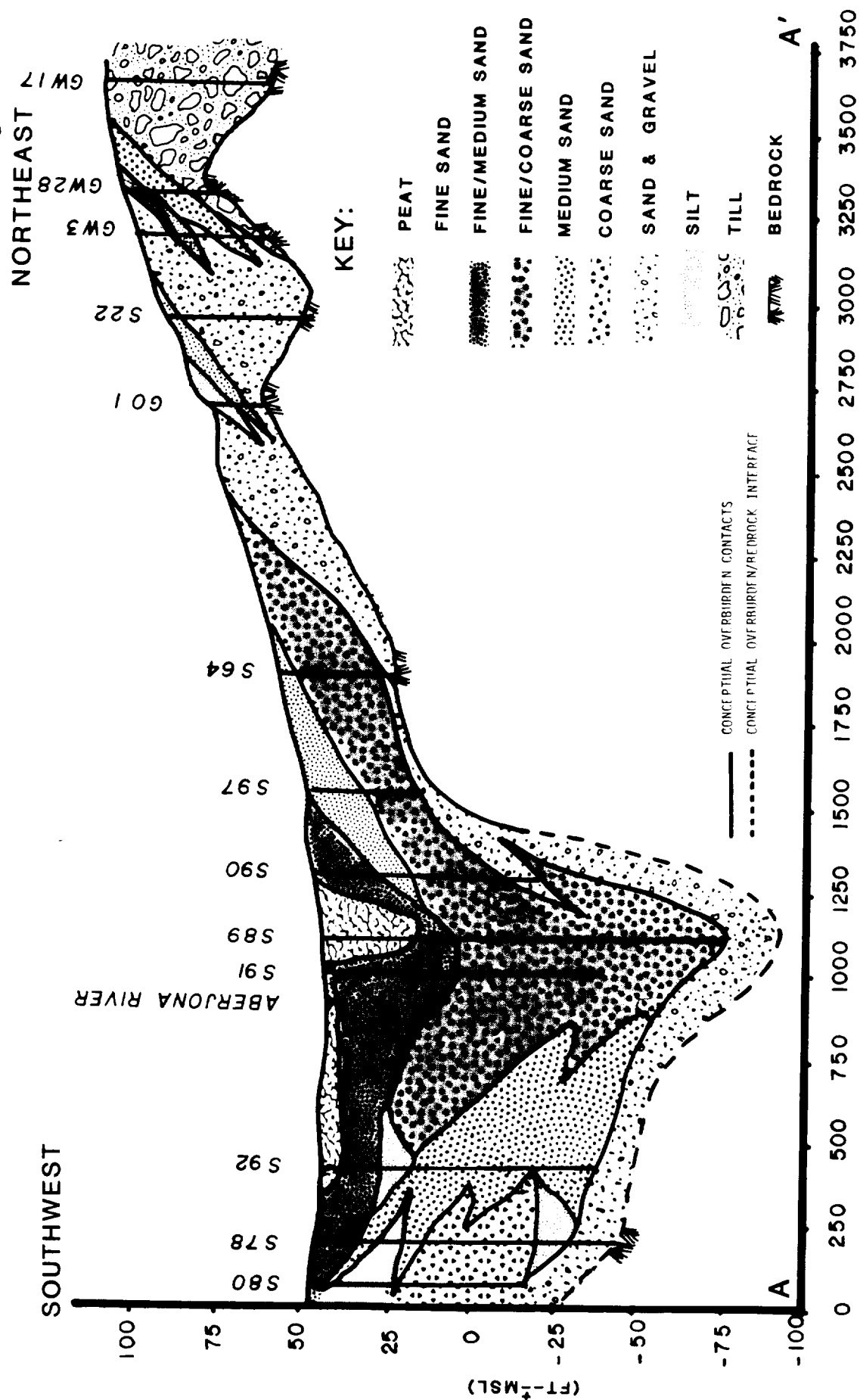
NUS/FIT identified two major glacial overburden units within the boundaries of the Wells G & H study area. These units were named for their probable modes of deposition and include a stratified drift unit and an ice contact unit. Characteristics of each unit are discussed in Section 4.1. The areal distribution of these units is depicted on Figure 4-5.



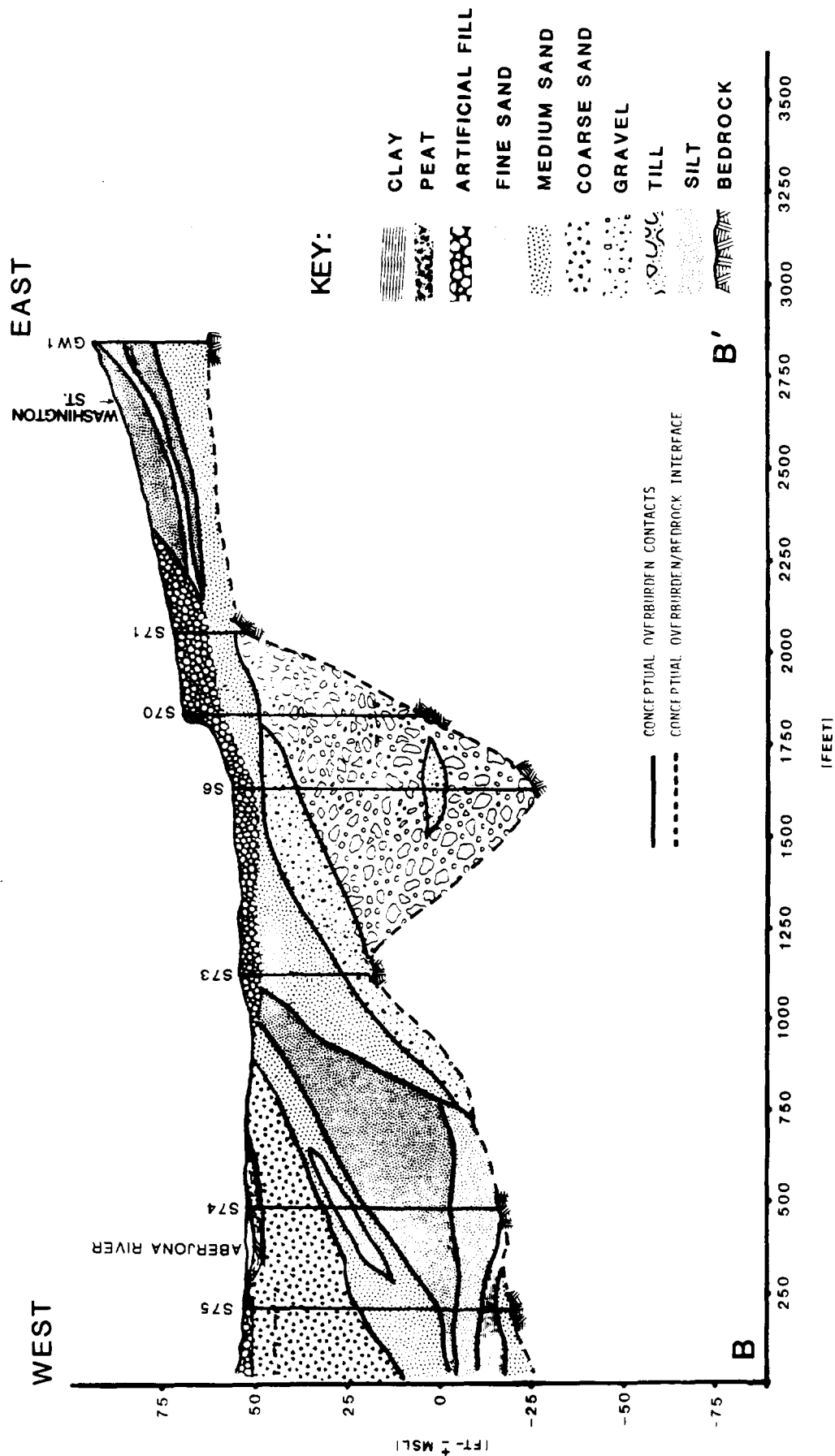
GEOLOGIC CROSS SECTION KEY
WELLS G AND H
WOBBURN, MA

NUS
CORPORATION
A Halliburton Company

FIGURE 4-1



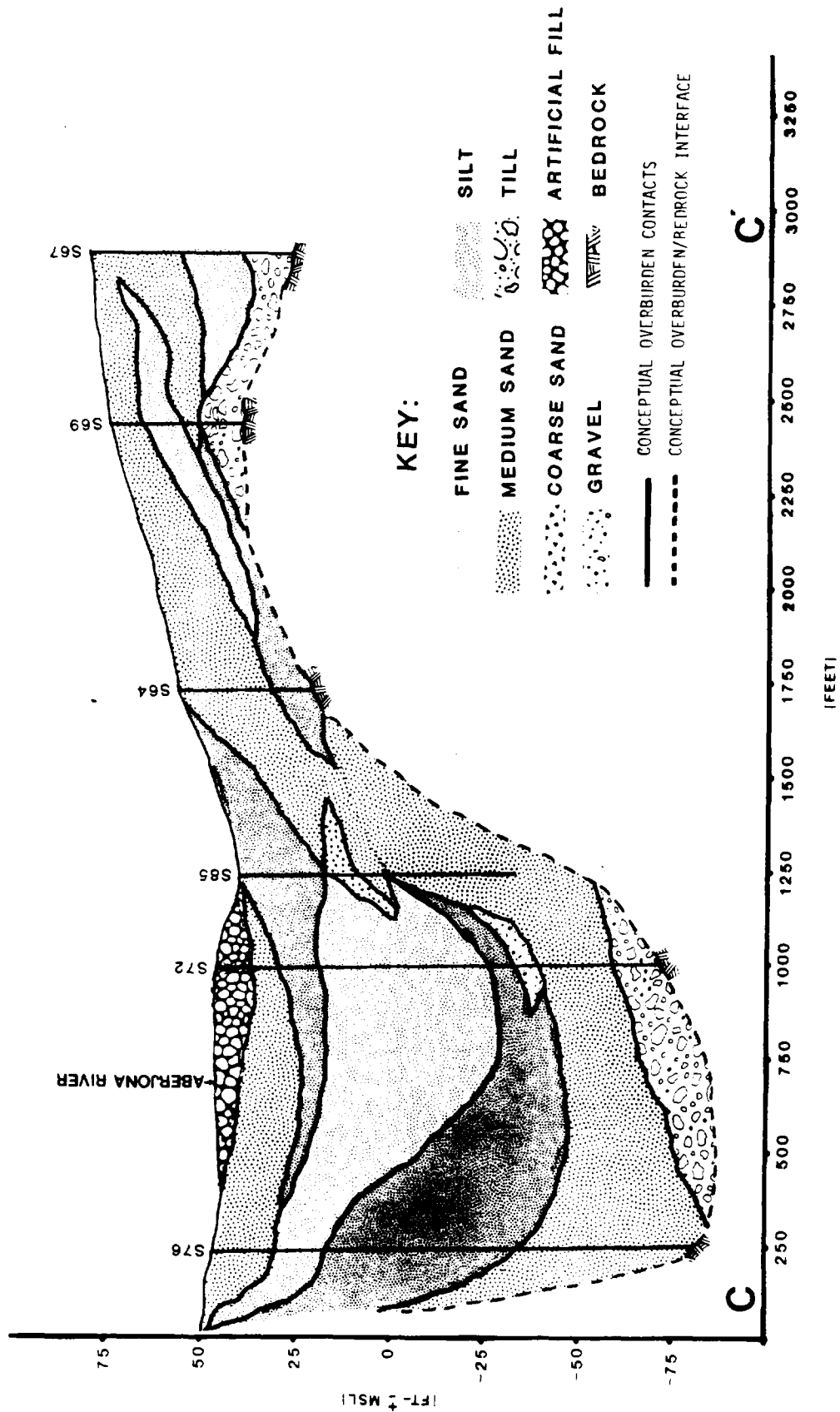
CROSS SECTION A-A'
 WELLS G&H
 WOBURN, MA



CROSS SECTION B-B'
WELLS G&H
WOBURN, MA

WEST

EAST

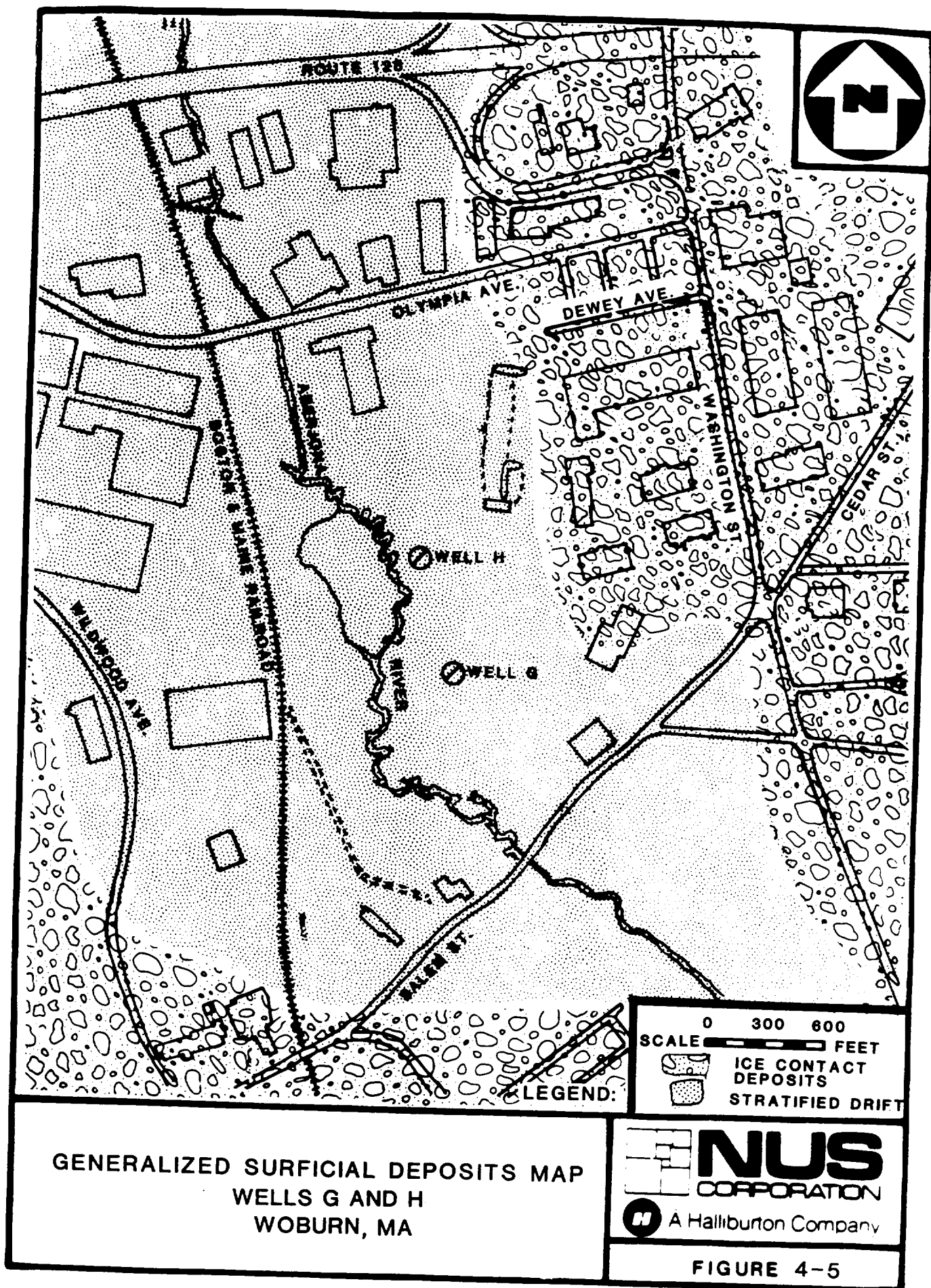


CROSS SECTION C-C'
WELLS G&H
WOBBURN, MA



A Halliburton Company

FIGURE 4-4



The deposition of surficial deposits was controlled to some extent by the bedrock topography. The most prominent bedrock feature is a fault-controlled buried bedrock valley. This buried valley was probably widened and deepened during Pleistocene glaciation. The valley has gently sloping walls, but locally may be very steep (Ecology and Environment, 1982b).

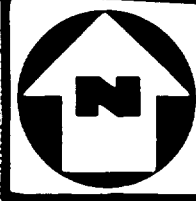
Two bedrock formations (Salem Gabbrodiorite, Dedham Granodiorite) were identified as underlying the study area; their characteristics and relationship to one another are discussed in Section 4.2. The areal distribution of bedrock types is depicted in Figure 4-6.

4.1 Surficial Geology

Characterization of the surficial geology of the Wells G & H site was an important aspect of the NUS/FIT Remedial Investigation. As noted in previous sections, solvents were allegedly disposed of directly into the ground with no artificial containment. For this reason, the composition of the surficial geologic materials at the site is a critical factor in assessing contaminant migration.

Information describing regional surficial geology was obtained through review of available published literature. Site-specific information was developed through review of previous investigators' findings and through surface and subsurface investigative work conducted by NUS/FIT during the course of the Remedial Investigation. The collective findings of these efforts are summarized below.

The surficial geologic units underlying the Wells G & H site consist of a complex mixture of glacial and fluvial deposits. The collective thickness of these units can exceed 135 feet as observed during the installation of monitoring well S77 (Plate 1). The stratigraphic relationship among the valley deposits beneath the study area is illustrated in a series of three interpretive geologic cross sections, which were prepared from information obtained during the drilling and installation of NUS/FIT monitoring wells (S63 through S86). This information was



GENERALIZED BEDROCK MAP
WELLS G AND H
WOBBURN, MA

NUS
CORPORATION
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FIGURE 4-6

supplemented with data collected by the previous FIT contractor as well as by data obtained through field investigations conducted by other firms. Figure 4-1 shows the locations of the cross sections that are presented as Figures 4-2 through 4-4.

The overburden deposits encountered in the valley flat consist of stratified gravel, sand, silt and clay. Stratification was noted throughout the majority of the study area through collection of split spoon samples at every five feet during drilling/well installation. In general, the uppermost valley flat deposits are associated with the Aberjona River system and consist primarily of interbedded silty peat and sandy peat strata. These deposits are confined to the lower topographic elevations immediately surrounding the river channel and extending the width of the valley flat. The thickness of the peat deposit averages between four and six feet, however, a 30 foot thick peat and organic silt deposit was encountered during the installation of well S89 for the joint EPA/USGS aquifer test. The organic silt unit seems to be localized in the vicinity of Well H and was not encountered at any other location in the study area. Cross-section A-A' (Figure 4-2) shows the proximity of the peat and organic silt units to Well H.

Directly underlying the alluvial deposits are brown to gray, fine to coarse sands and gravel with traces of silt. The thickness of this stratum ranges from 5 to 50 feet in the immediate vicinity of Wells G & H. In general, grain size of the particles decreases with depth with fine to medium sands and silt extending approximately another 30 feet in thickness. A sand and gravel unit was encountered below the fine materials at approximately 70 to 80 feet in depth along the eastern flank of the valley. It is within these sand and gravel deposits that Wells G & H are screened.

At well locations S72, S73, S77, S78, S79, and S80, 20 to 50 feet of interbedded blue to gray very fine sands, silts and clays were encountered. This material is thickest in the deepest portions of the valley and decreases in thickness toward the valley walls. These materials appear to be confined to the central sections of the valley. The small particle size of this unit indicates deposition in a low energy regime such as that of a lake or pond. Directly underlying the fine grained, blue gray deposits are coarser sand and gravel with cobbles and boulders.

The surficial deposits found in the higher elevations of the site do not reflect the same high degree of sorting found in the deposits that fill the valley flat. Based on the in-situ density and lack of sorting, this material has been interpreted as an ablation till/ice contact unit which was deposited as the underlying glacial ice melted. Contained within the till body are lenses of sorted sands and gravels (Figure 4-3). These lenses represent sorting by melt waters. Ablation till is characterized by a high sand and gravel percentage with varying amounts of silt (Ritter, 1978). Ablation till was encountered during the installation of well S70. The till apparently fills a bedrock low which may have protected it from being reworked by the glacial melt waters (Figure 4-3).

NUS/FIT also identified a basal or lodgement type till in the study area during installation of wells S67 and S86. In the deposition of lodgement till, sediments are plastered against the underlying bedrock surface beneath the ice flow. Because of the extreme weight of the overlying ice and debris, and relatively high water content resulting from pressure melting, lodgement tills are generally very dense (Sugden et al, 1977, Goldthwait, 1948).

The tills encountered during the NUS/FIT Remedial Investigation do not form a continuous mantle, but instead appear to generally occupy bedrock depressions (Figure 4-3). Overlying the tills on the eastern flank are gravels, sands and some silts of varying thickness. These sediments are believed to have been deposited as glacial meltwaters washed over the highlands to the valley.

4.2 Bedrock Geology

The Wells G & H study area is situated within the Appalachian Mountain orogenic belt in an area mapped as the Brittlely Deformed Terrane by Zen et al. (1983) and consists of a diorite and gabbro complex with secondary metavolcanic rocks and intrusive granite and granodiorite. These units have been severely distorted by faults and associated fracturing which has dissected the area into small blocks and slices. Where faulting has occurred, the original character of the rock is locally

altered to produce a finer grained, highly foliated rock which may be more susceptible to weathering. The weathering of the faulted materials is believed to have produced the bedrock troughs found in the study area (Plate 3). With the onset of glaciation, the bedrock troughs afforded preferential pathways for the accumulating glacial mass. Differential plucking of the more weathered, less resistant rock likely resulted in the widening and deepening of the valley immediately surrounding the fault. It is through these mechanisms that the bedrock valley beneath the Aberjona River is believed to have been formed.

There are two major rock types underlying the Wells G & H aquifer area. They were identified by the previous EPA FIT contractor (Ecology & Environment, 1982a) as the Dedham Granodiorite and Salem Gabbrodiorite, respectively. Based on mineral assemblages and physical description, NUS/FIT concurs with these designations.

The Dedham Granodiorite is believed to be the older rock unit and dates to the Precambrian. It is characteristically a grayish-pink, coarse grained, moderately foliated, biotite-hornblende quartz feldspar granodiorite (Ecology and Environment, 1982a). Rock quality designation calculations indicate that this unit is slightly to moderately fractured (Table 4-1).

The Salem Gabbrodiorite is Precambrian to Ordovician in age. It is medium to coarse-grained, bluish gray in color and is composed of hornblende, quartz and feldspar. The rock is highly fractured (Table 4-1) and altered. Quartz veins are present throughout this unit (Ecology and Environment, 1982a).

The bedrock topography was interpreted within the context of the scoured glacial valley model. Bedrock surface elevations were developed using borehole logs from the newly installed NUS/FIT monitoring wells (S63-S86) in conjunction with data collected during previous investigations (Ecology and Environment, 1982a; GeoEnvironmental, 1983; WWC, 1984a and 1984b; ERT, 1984). Due to the number of data points available, NUS/FIT was able to develop a bedrock surface elevation map with ten foot contour intervals. Table 4-2 presents the elevations used to develop bedrock topography (Plate 3)

**TABLE 4-1
BEDROCK CORING RESULTS**

Well No.	Coring Run No.	Cored Depth (feet)	Length Cored (inches)	RQD (%)	Rock Quality Description
S63	1	26-31	60	83.83	Good
S63	2	31-36	60	100	Excellent
S64	1	36-41	60	15.83	Very Poor
S64	2	41-46	60	59.17	Fair
S64	3	46-51	60	77.50	Good
S64	4	51-56	60	97.50	Excellent
S65	1	39.2-44.2	60	63.33	Fair
S65	2	44.2-49.2	60	60.00	Fair
S65	3	49.2-54.2	60	85.00	Good
S65	4	54.2-59.2	60	63.33	Excellent
S66	1	14.7-19.7	60	78.18	Good
S66	2	19.7-24.7	60	91.67	Excellent
S66	3	24.7-29.7	60	75.00	Good
S66	4	29.7-34.7	60	98.33	Excellent
S67	1	55-60	60	36.67	Poor
S67	2	60-65	60	66.67	Fair
S67	3	65-70	60	58.33	Fair
S67	4	70-75	60	41.67	Poor
S68	1	107.5-112.5	60	65.00	Fair
S69	1	35-40	60	25.83	Poor
S69	2	40-45	60	51.67	Fair
S69	3	45-50	60	74.17	Fair
S69	4	50-55	60	45.83	Poor
S70	1	63-68	60	23.33	Very Poor
S70	2	68-73	60	76.67	Good
S70	3	73-78	60	50.00	Fair
S70	4	78-83	60	86.67	Good

The relationship of RQD values to descriptive rock quality is as follows:

- 90-100%: excellent
- 75-90%: good
- 50-75%: fair
- 20-50%: poor
- 0-25%: very poor

**TABLE 4-1
BEDROCK CORING RESULTS PAGE TWO**

Well No.	Coring Run No.	Cored Depth (feet)	Length Cored (inches)	RQD (%)	Rock Quality Description
S71	1	20-25	60	76.67	Good
S71	2	25-30	60	78.33	Good
S71	3	30-33.5	42	61.90	Fair
S71	4	33.5-38.5	60	43.33	Poor
S71	5	38.5-42.7	50	38.9	Poor
S72	1	117-120	36	0	Very Poor
S72	2	122-127	60	0	Very Poor
S72	3	127-132	60	61.67	Fair
S72	4	132-137	60	58.33	Fair
S73	1	36.5-41.5	60	37.50	Poor
S73	2	41.5-46.5	60	75.00	Fair
S73	3	46.5-51.5	60	28.33	Poor
S73	4	51.5-56.5	60	15.00	Very poor
S74	1	68.5-73.5	60	28.33	Poor
S74	2	73.5-78.5	60	62.50	Fair
S74	3	78.5-83.5	60	72.50	Fair
S74	4	83.5-88.5	60	64.17	Fair
S75	1	75-80	60	76.67	Good
S75	2	80-85	60	71.67	Fair
S75	3	85-90	60	19.17	Very Poor
S75	4	90-95	60	51.67	Fair
S76	1	130-135	60	50.83	Fair
S76	2	135-140	60	60.83	Fair
S76	3	140-145	60	40.00	Poor
S76	4	145-150	60	98.33	Excellent

The relationship of RQD values to descriptive rock quality is as follows:

- 90-100%: excellent
- 75-90%: good
- 50-75%: fair
- 20-50%: poor
- 0-25%: very poor

TABLE 4-1
BEDROCK CORING RESULTS PAGE THREE

Well No.	Coring Run No.	Cored Depth (feet)	Length Cored (inches)	RQD (%)	Rock Quality Description
S78	1	90.5-95.5	60	76.67	Good
S78	2	95.5-100.5	60	70.83	Fair
S78	3	100.5-105.5	60	13.33	Very Poor
S78	4	105.5-110.5	60	10	Very Poor
S79	1	107.5-112.5	60	87.50	Good
S79	2	112.5-117.5	60	96.67	Excellent
S79	3	117.5-122.5	60	97.50	Excellent
S79	4	122.5-127.5	60	0	Very Poor
S81	1	62.5-67.5	60	58.33	Fair
S81	2	67.5-72.5	60	74.17	Fair
S81	3	72.5-77.5	60	87.50	Good
S81	4	77.5-82.5	60	80.00	Good
S84	1	81.5-86.5	60	73.33	Fair
S84	2	86.5-91.5	60	63.33	Fair

The relationship of RQD values to descriptive rock quality is as follows:

- 90-100%: excellent
- 75-90%: good
- 50-75%: fair
- 20-50%: poor
- 0-25%: very poor

TABLE 4-2
BEDROCK ELEVATIONS
USED IN CONSTRUCTION OF BEDROCK TOPOGRAPHIC MAP

Well Number	Ground Surface Elevation	Depth To Bedrock	Bedrock Elevation
IUS1	87.6	11.5	76.1
IUS2	61.3	53.6	7.7
IUS3	66.9	55.2	11.7
S5	48.9	54.5	-5.6
S6	62.3	40.6	21.7
S11	42.9	75.0	-32.1
S21	79.6	22	57.6
S22	77.2	37	40.2
S60	122.4	24	98.4
S63D	69.5	22.0	47.5
S64D	57.8	35.0	22.8
S65D	76.9	39.2	37.7
S66D	69.6	11.5	58.1
S67D	83.3	54.0	29.3
S68D	45.5	105	-59.5
S69D	75.4	36	39.4
S70D	69.4	62	7.4
S71D	71.4	16.5	54.9
S72D	50.2	116	-65.8
S73D	52.0	35	17
S74D	48.2	67.5	-19.3
S75D	56.9	75	-18.1
S76D	53.0	130	-77
S77D	44.9	>135	-90.1
S78D	45.8	90.5	-44.7
S79D	47.4	107.5	-60.1
S80M	55.4	>70	-14.6
S81D	54.1	62	-7.9
S82	57.0	>45	<12
S83D	48.1	>87	-38.9
S84D	46.2	81.5	-35.3
S85M	46.1	>70	<23.9
S86D	43.3	>62	<18.7

TABLE 4-2
BEDROCK ELEVATIONS
USED IN CONSTRUCTION OF BEDROCK TOPOGRAPHIC MAP
PAGE TWO

Well Number	Ground Surface Elevation	Depth To Bedrock	Bedrock Elevation
GW1D	97.8	34.5	63.4
GW2D	97.4	29.0	68.4
GW3D	91.7	38.6	53.1
GW4D	93.6	24.5	69.1
GW5D	93.8	19.5	74.3
GW7D	96.8	28.5	68.3
GW11D	91.2	24	67.2
GW12D	93.4	25.5	67.9
S97D	51.0	33.5	17.5
BW8	45.4	61.5	-16.1
BW9	46.0	28.7	17.3
BW10	46.5	39.5	7
BW13	46.6	57.5	-10.9
S41	60.0	38.0	22

NOTE:

- > indicates bedrock lies at a depth greater than the penetrated thickness
- <12 indicates the bedrock surface is at an elevation less than the elevation (eg. 12) listed, with respect to Mean Sea Level

The central axis of the buried valley grades from north to south with its position in the valley approximated by the current course of the Aberjona River. From this axis, the bedrock surface rises gradually to the east and west. The slope markedly increases at the trough edges lending the characteristic U-shape of the glacial valley. The steepest grades occur along the eastern flank of the valley where the bedrock surface rises abruptly to form the bedrock highlands that underlie the higher elevations in the area.

There is a correlation between bedrock lithology and bedrock surface elevations. In general, the rock type found underlying the deeper deposits, within the buried valley, is the Salem Gabbrodiorite (Figure 4-6). It is theorized by NUS/FIT that the Salem was more easily fractured, and therefore excavated through glacial plucking and scouring, than the more highly resistant Dedham Granodiorite which underlies the higher elevations. Such selectivity of glacial erosion has been described in a number of regional studies (Sugden and John, 1976). A characteristic of this type of erosion is a very steep slope to the trough edge. This feature was demonstrated during the installation of well S84. Bedrock outcrops with surface elevations of approximately 50 feet above MSL are located within 200 feet of the well boring, yet bedrock was not encountered until 45 feet below MSL in the well boring.

Other features inferred from the bedrock surface elevations are smaller, less pronounced troughs and swales that are tributary to the main bedrock trough. These features are evident in the bedrock formation which underlies the eastern half of the site. Zones of weakness in the bedrock were recorded during the installation of monitoring wells S8 and S22. Fault gouge and brecciated rock were recovered from boreholes (S8, S69, S21). No other zones exhibiting such intense deformation were encountered by NUS/FIT in the study area.

4.3 Hydrogeology

The previous section described the geologic framework of the Wells G & H aquifer area in terms of surficial and bedrock geology. This section presents information

on the occurrence of groundwater within this framework. For purposes of organization, this section is subdivided into Subsection 4.3.1 Hydrologic Setting, Subsection 4.3.2 Hydrogeology of Surficial Units, and Subsection 4.3.3 Hydrogeology of Bedrock.

This information is derived from a variety of sources including published reports on regional conditions, reports of investigative activities prior to the NUS/FIT Remedial Investigation and information acquired during NUS/FIT field activities conducted for the Remedial Investigation.

4.3.1 Hydrogeologic Setting

The two primary sources of recharge to the aquifer from which Wells G & H withdrew groundwater have been identified as: infiltration of precipitation throughout the aquifer area, and surface and groundwater recharge from the bedrock highlands (Ecology and Environment, 1982a).

A third potential source of recharge to the Wells G and H aquifer area is the Aberjona River. This possibility will be discussed in light of data collected during the groundwater monitoring well installation phase of the Remedial Investigation in Subsection 4.3.2 Hydrogeology of Surficial Units. Further data on the Aberjona River/Wells G & H aquifer area relationship was collected during the EPA/USGS aquifer test conducted during December, 1985 (Section 3.10).

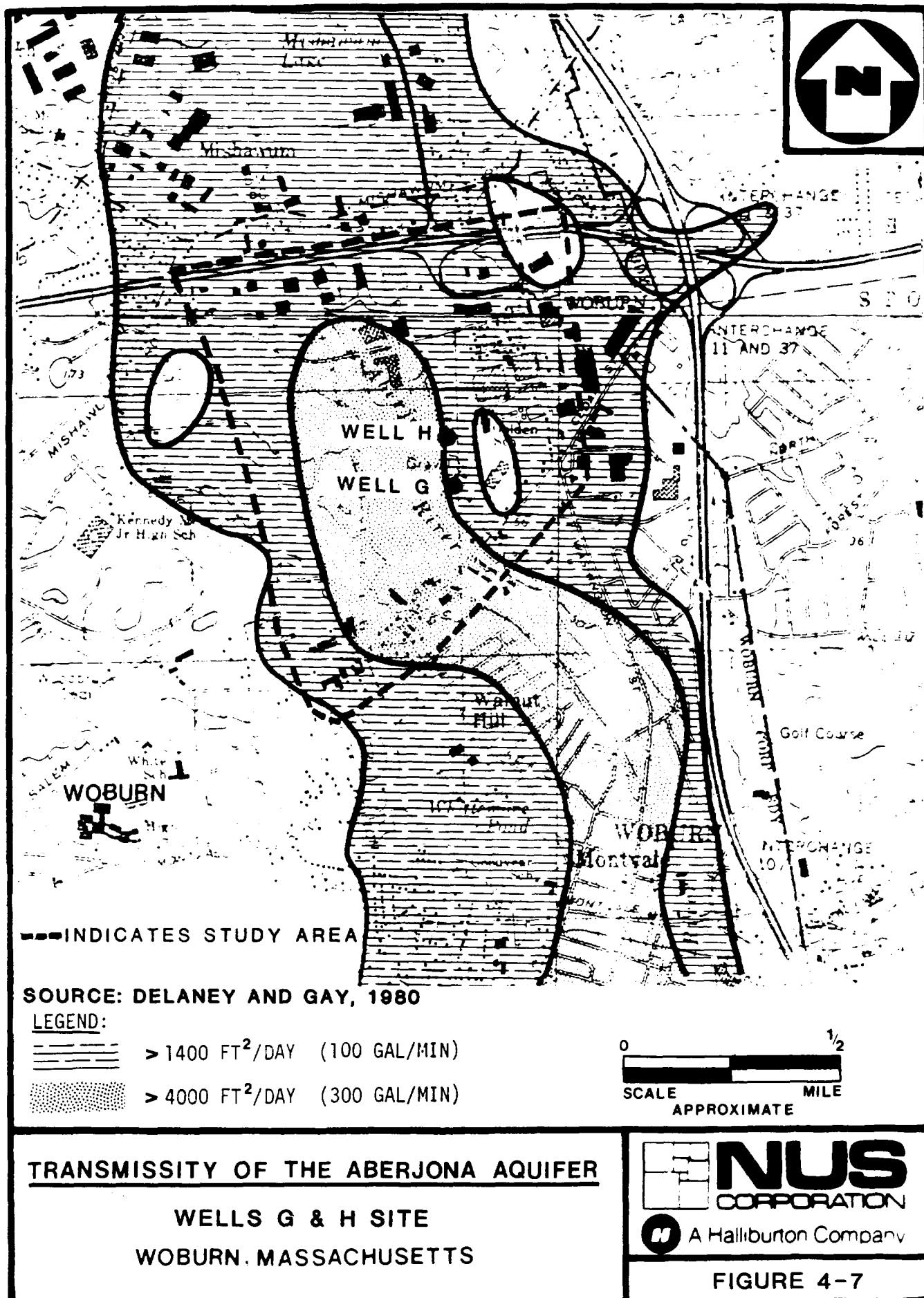
Approximately 20 inches of surface water runoff is generated annually in the Woburn area from an average annual precipitation of 44 inches (USGS, 1977). Some of the remaining 24 inches of precipitation percolates through the surficial deposits to become groundwater. Previous studies (Delaney and Gay, 1980) of the hydrology of the Mystic River Drainage Basin, and the Aberjona River Drainage Basin, which includes the Aberjona River system, indicate that the study area is in large part underlain by a highly productive aquifer. The Wells G & H aquifer area consists of the glacial deposits discussed in Section 4.1, Surficial Geology; it is located entirely within the Aberjona River Watershed. The Aberjona River, which drains

the watershed, has its headwaters in Reading, Massachusetts, and flows to the south 8.7 miles before discharging to the Upper Mystic Lake (MDC, 1977). Approximately eleven percent of its length is within the study area.

The estimated transmissivity of the stratified drift deposits within the Wells G & H aquifer area is in excess of $4,000 \text{ ft}^2/\text{day}$. Transmissivity is a measure of the ability of a unit to conduct groundwater flow. The higher the transmissivity of the unit, the more readily groundwater can flow through the deposit. Wells G & H are located in what is mapped as the most transmissive unit in the Aberjona aquifer (Delaney and Gay, 1980). Figure 4-7 reproduces a portion of the transmissivity map developed by Delaney and Gay in 1980. The Wells G & H study area is outlined on this figure. The USGS reported estimated transmissivities of 29,700 square feet per day near Well G and $20,700 \text{ ft}^2/\text{day}$ at Well H (USGS, 1986). The average horizontal hydraulic conductivity at Well G is 350 feet per day and 235 feet per day at Well H (USGS, 1986). Local historical water table measurements compiled by the USGS indicate annual water level variations of up to five feet in the study area (Maevsky, 1974; USGS, 1980). The highest levels occur between early November and late April with the lowest levels occurring in August, September, and early October. These variations are typical of New England and reflect seasonal changes in the rate of groundwater recharge.

4.3.2 Hydrogeology of Surficial Units

One of the overall objectives of the NUS/FIT monitoring well installation program was to provide site specific information on groundwater conditions, both in terms of groundwater occurrence and groundwater quality. As part of the Remedial Investigation, NUS/FIT installed 55 wells at 24 locations. To complement already existing wells in the area, thirty-eight of these wells are screened only in surficial (overburden) geologic materials. The remainder are screened in bedrock. Table 3-2 lists the total depth, ground elevation and elevations of the screened intervals of each NUS/FIT well. Table 4-3 lists the water level measurements taken on April 2, 3 and 4, 1985 that were used in conjunction with elevation



BASE MAP IS A PORTION OF THE U.S.G.S. LEXINGTON BOSTON NORTH READING & WILMINGTON QUADRANGLES (7.5" SERIES, 1971-1979)

TABLE 4-3
WATER TABLE ELEVATIONS USED
IN CONSTRUCTION OF
WATER TABLE MAP
(MEASUREMENTS IN FEET FROM APRIL 2,3,4, 1985)

Well Number	Elevation of Ground Surface	Depth To Groundwater From Ground Surface	Elevation of Groundwater
IUS 1	88.4	12.2	76.2
IUS 2B	61.3	4.4	56.9
IUS 3C	66.9	7.7	59.2
S5	48.9	2.5	46.4
S6	62.3	7.4	54.9
S7	95.1	3.7	91.4
S11	42.9	11	41.8
S21	77.2	18.7	58.5
S63S	70.0	12.3	57.7
S64M	57.7	2.8	54.9
S65M	77.0	20.4	56.6
S67M	83.3	14.4	68.9
S68S	45.2	1.3	43.9
S70M	70.0	13.2	56.8
S71S	71.4	11.3	60.1
S72M	50.9	5.5	45.4
S73S	52.6	4.4	48.2
S74M	48.0	1.2	46.8

TABLE 4-3
WATER TABLE ELEVATIONS USED
IN CONSTRUCTION OF
WATER TABLE MAP
(MEASUREMENTS IN FEET FROM APRIL 2,3,4, 1985)
PAGE TWO

Well Number	Elevation of Ground Surface	Depth To Groundwater From Ground Surface	Elevation of Groundwater
S75M	56.7	8.5	46.2
S76M	52.4	6.6	45.8
S77M	44.7	2.0	42.7
S78S	45.4	2.0	43.4
S79M	48.0	4.2	43.8
S80M	48.7	4.9	43.8
S81M	55.4	4.2	51.3
S82	57.0	4.8	52.2
S83	48.1	6.3	41.8
S84M	46.0	2.2	43.8
S85M	46.0	1.6	44.4
S86S	44.7	1.3	43.4
GW1S	97.8	9.3	88.5
GW2M	98.5	8.1	90.4
GW3S	92.3	23.9	68.4
GW4S	95.7	12.0	83.7
GW5S	93.1	11.1	82.0
GW7	96.0	10.0	86.0

measurements of surface water bodies and consideration of surface and bedrock topography to prepare a water table (potentiometric surface) map of the site (Plate 4). The locations of the data points and their respective water level elevations are provided on the plate. The water table within the study area mimics the bedrock surface in a subdued manner. It exhibits an overall troughlike shape with its axis trending north to south. The main axis of the water table trough has a gradual hydraulic gradient of approximately five feet/mile as calculated from water level measurements recorded at monitoring well S5 in the north and S11 in the south of the study area. As shown on Plate 4, the steepest hydraulic gradients occur in the northeast section of the site. The calculated hydraulic gradient between wells GW1 and S63 is 151 ft/mile. Groundwater flows in a westerly to southwesterly direction beneath the northeast area of the site eventually discharging to the lower elevations of the bedrock valley.

There is a water table divide partially identified by wells GW6, GS7 and GW8. Groundwater near and east of these wells flows south and southeast.

The hydraulic gradient under static (non-pumping) conditions is controlled by many factors including gravity and the permeability of the deposits through which the groundwater flows. The variation in hydraulic gradients across the sandy till/ice contact deposits in the northeastern area of the site reflects in part the inhomogeneity of the deposits that comprise this unit. The overburden underlying the Dewey Street area appears to support a steeper hydraulic gradient with respect to the remainder of the highlands, which is indicative of material with lower hydraulic conductivity (such as a more dense till) underlying this area.

The groundwater flow in the area north of Olympia Avenue has a strong westerly component. The direction of groundwater flow under this area is westward, but becomes increasingly southwesterly as it continues downslope.

Permeabilities of the surficial geologic materials encountered in the area were estimated through sixteen in-situ permeability tests and from laboratory grain size analyses of overburden samples. The range of permeabilities garnered from this

testing are consistent with permeabilities determined for similar unconsolidated deposits (Freeze and Cherry, 1979). Appendix F presents the methods, raw data, and results of the in-situ testing, as well as the remainder of the permeabilities estimated solely through grain size analysis.

Wells G & H are screened in the most permeable surficial deposit (stratified drift) in the study area (Delaney and Gay, 1980). They are capable of yielding 800 and 700 gallons per minute, respectively (Delaney and Gay, 1980b). The John J. Riley, Tannery Production Well No. 2 (S46), estimated to be capable of yielding 750 gallons per minute, draws water from the same stratified drift aquifer (Delaney and Gay, 1980b). The combined effect of simultaneous operation of Wells G & H and the Riley Production Well No. 2 (S46) has not been determined. Data collected during the EPA/USGS aquifer test is expected to establish the effect of combined withdrawal on the aquifer and will be presented in the USGS final aquifer test report.

Due to variations in depositional environment, the till and ice-contact deposits overlying the bedrock highlands vary areally and vertically in the inability to transport groundwater. As noted in Section 4.1, the till contains lenses of relatively well-sorted sand and gravel which may form preferred flow paths. These lenses may be able to transmit large volumes of groundwater to the Wells G & H aquifer area depending on the degree of interconnection between the relatively more permeable members of the unit.

The fine deposits in the valley (S80, S79, S77) are considerably less permeable than the coarse-grained glaciofluvial unit in which Wells G & H are screened and may tend to act as an aquitard. Water flowing to Wells G & H would more readily flow beneath this unit (aquitard) through the coarse sand and gravel that overlies the bedrock surface.

Overlying the glacial deposits within the valley flat are the alluvial and swamp deposits associated with the Aberjona River and surrounding wetlands (Section 4.1). Silty peat and sandy peat deposits are typically low in permeability with a reduced

ability to transmit water. However, the variability of composition of the peat due to such factors as the reworking of the alluvial deposits by the meandering of the (Aberjona) river, the frequency and extent of flooding, as well as variation in vegetation may yield variable permeabilities in such units (Motts and Obrien, 1981).

4.3.3 Hydrogeology of Bedrock

As noted in Section 4.2, the bedrock underlying the Wells G & H aquifer area consists of crystalline igneous rocks. Rock of this type has virtually no ability to transmit water except through fractures. This ability to transmit water is largely dependent upon the extent of fracturing, including the size, orientation, and degree of interconnection of the fractures.

Wells intercepting systems of interconnected fractures are found throughout the Aberjona River Valley (Delaney and Gay, 1980). There is currently one bedrock well in use within the study area. It is located at New England Plastics Company approximately 750 feet due east of Well G and is indicated as well S41 on Plate 1. The well is 358 feet deep and has a reported yield of at 45 gallons per minute (Delaney and Gay, 1980).

An abandoned bedrock well located in the proximity of well S21, in West Cummings Park, was formerly used by the Johnson Bros., Inc. This well was 364 feet deep and was reported to yield 110 gallons per minute (Delaney and Gay, 1980).

This information suggests that the bedrock beneath the site is sufficiently fractured to support modest to moderate groundwater yields. This interpretation is further supported by bedrock coring collected by NUS/FIT during the installation of eighteen bedrock monitoring wells. The rock quality designations (RQDs) calculated for each core indicate that a high degree of fracturing in shallow bedrock is pervasive throughout the study area (Table 4-1). The fracturing detected in the upper bedrock suggests that recharge to the bedrock aquifer is derived at least in part from the overlying glacial deposits.

5.0 ANALYTICAL RESULTS

Presented in this chapter are the analytical results generated during the NUS/FIT Remedial Investigation. Data presented in this section are from the following sampling rounds:

- initial NUS/FIT sampling round for NUS/FIT analytical screening
- sampling of the recently installed NUS/FIT wells for NUS/FIT screening
- April, May, and June, 1985 NUS/FIT sampling rounds for contract laboratory program (CLP) analysis

Due to the large amount of analytical data, all tables of analytical results are presented in Appendix G. Discussion of analytical results will include the NUS/FIT data summarized above as well as analytical data collected by other contractors at the W.R. Grace, Wildwood Conservation Corporation, and UniFirst sites and data collected by EPA from the Army Corps of Engineers (COE) wells (S87-S97). These additional data are presented in Appendix C.

Analytical results for overburden and bedrock groundwater and surface water samples will be discussed separately. The concentrations of Hazardous Substance List (HSL) volatile organic compounds, extractable organic compounds (acid and base/neutral extractable compounds, pesticides and polychlorinated biphenyls), and metals will be presented. Results of federal and state drinking water quality analyses will be presented in Section 5.2.4.

5.1 Sampling and Analysis Efforts

As described in Section 3.2, a total of 52 samples were collected from 34 monitoring wells, three surface water locations, and three sediment locations during the initial sampling round (July, 1984) for in-house volatile organic screening (Table 3-1). This included 23 samples collected by NUS/FIT and 11 split samples collected by Woodward-Clyde Consultants at the Wildwood Conservation

Corporation site. After each monitoring well was installed, groundwater sampling was conducted for NUS/FIT volatile organic screening. After the well installation program was completed, NUS/FIT performed three final sampling rounds for CLP analysis with one round completed each month for the months of April, May, and June, 1985. These samples were analyzed for HSL volatile organic compounds, extractable organic compounds, and metals as detailed in Tables 3-3, 3-4, and 3-5. Selected samples were also analyzed for the federal and state drinking water quality parameters listed in Table 3-7. These results will include some duplication of the HSL parameters and/or analyses. Specifically, drinking water quality analyses include six additional extractable organic compounds (the herbicides 2,4-D and 2,4,5-TP; and the pesticides endrin, lindane, methoxychlor, and toxaphene) and eleven HSL inorganic substances (arsenic, barium, cadmium, chromium, lead, mercury, nitrate, selenium, silver, fluorine, and sodium).

Analytical methods for NUS/FIT screening as well as CLP analytical protocols are presented in Appendix D. A quality control review (data validation) was conducted on all CLP analytical data. A summary of the data validation protocol is also presented in Appendix D.

5.2 Groundwater Analytical Results

Groundwater contaminants in the study area consisted primarily of volatile organic compounds. The most common volatile organic contaminants detected were trichloroethene (TCE); trans-1,2-dichloroethene (trans-1,2-DCE); 1,1,1-trichloroethane (1,1,1-TCA); and tetrachloroethene (TETRA). The extractable compounds detected were: 1,2-dichlorobenzene; bis(2-ethylhexyl)phthalate; phenol; benzoic acid; naphthalene; 2-methylnaphthalene; chlordane; acenaphthylene; acenaphthene; phenanthrene; fluoranthene; and chrysene. These extractable organic compounds, for the most part, were identified in samples from the southwestern portion of the study area and at well location S75 in the northwestern corner of the study area. The NUS/FIT results are comparable with earlier E & E analytical data described in Section 2.0. At the time of this writing, regulatory levels such as maximum contaminant levels (MCLs) have not been established for these volatile and extractable organic compounds.

All HSL inorganic elements, with the exception of antimony (Sb) and selenium (Se), were detected in groundwater at varying concentrations. A pattern of distribution of the elements throughout the study area was not demonstrated. The inorganic element chromium (Cr) was detected at concentrations greater than the National Interim Primary Drinking Water Regulations Maximum Contaminant Levels (MCLs). Sodium (Na) was detected at concentrations greater than the federal advisory level of 20 mg/l. Iron (Fe) and manganese (Mn) were detected at concentrations in excess of the National Secondary Drinking Water Regulations Maximum Contaminant Levels (SMCLs).

5.2.1 Volatile Organic Analytical Results

The screening results from the initial round of sampling are presented in Appendix G (Table 1). The predominant groundwater contaminants detected were trichloroethene (TCE); trans-1,2-dichloroethene (trans-1,2-DCE); tetrachloroethene (TETRA); benzene; toluene; ethylbenzene; meta-xylene and ortho-xylene. All samples were screened by NUS/FIT chemists using a Photovac 10A10 gas chromatograph; compound identification is tentative and that the analytical results are to be considered semi-quantitative. The analyses confirmed earlier E & E data (Section 2.0) indicating groundwater contamination by TCE; trans-1,2-TCE; and TETRA. The highest concentrations (relative to all compounds detected) of most of these contaminants were detected in the northeastern (S21, GW3, and GW4) and southwestern (BW1 through BW7) portions of the study area. These data were utilized by NUS/FIT in monitoring well placement (Section 3.3).

Data generated from sampling the recently installed NUS/FIT wells, as presented in Appendix G (Table 2), were also used in subsequent monitoring well placement (Section 3.3). Although the screening protocol (Appendix D) is limited to selected volatile organic compounds, the analysis includes the most common volatile organic contaminants detected in the initial sampling round. No volatile organic compounds were detected at wells S69D, S70 (S & M), S73 (D only), S74 (M&D), S76,

(S, M&D), S77SS, S78D, S79 (M&D), and S80 (S&M). The majority of these monitoring wells are located in the northern and western portion of the study area (Plate 2). TCE was detected in 37 groundwater samples, with the highest concentrations in samples from well locations S63, S64, S68, S77, S78, S83, and S85. TETRA was detected in 32 groundwater samples; with the highest concentrations in samples from well locations S71D and S78S. Benzene, toluene, ethylbenzene, meta-xylene, and ortho-xylene were detected in samples from well S75 (S and M) only, but were not found to be prevalent elsewhere in the study area.

The predominant volatile organic compounds detected during CLP analysis in groundwater from the April, May, and June, 1985 sampling rounds were: TCE; TETRA; trans-1,2-DCE; 1,1,1-TCA; and 1,1-DCA. The CLP volatile organic data from the April, May, and June 1985 sampling rounds are presented in Appendix G (Tables 3, 4, and 5, respectively). Less frequently detected volatile organic compounds included: 1,1,2,2-tetrachloroethane; 1,2-dichloroethane; 1,1-dichloroethene; benzene; ethylbenzene; toluene; vinyl chloride; styrene; and xylenes. The CLP volatile organic results showed good correlation with the NUS/FIT volatile screening results.

Mean concentrations of certain selected volatile organic compounds for the three NUS/FIT sampling rounds are presented in Appendix G (Table 6). The volatile organic compounds selected represent the predominant as well as the less frequent volatile organic compounds detected and represent approximately 95 percent of the total volatile organic groundwater contaminants detected in the study area. Values not included in the calculation of the mean concentrations were:

- those values rejected as a result of the quality control review (data validation)
- those values determined by statistical analysis to be "outliers"

Outliers (those numbers determined to be anomalous) in groups of three or more data points were determined by a "Q" test as described by Dean and Dixon (1951) and were removed from the mean calculations. A table of mean concentrations

and the values used to calculate the means is presented in Appendix G (Table 6). Henceforth, any reference made to mean concentrations of volatile organic compounds or mean concentrations of total volatile organic compounds will indicate the mean concentrations of the selected volatile organic compounds listed in Table 6 (Appendix G).

The distribution of volatile organic compounds is depicted on Plates 5 through 9 as follows:

- Plate 5 Mean Concentrations of Total Volatile Organic Compounds
- Plate 6 Mean Concentrations of TCE
- Plate 7 Mean Concentrations of trans-1,2-DCE
- Plate 8 Mean Concentrations of 1,1,1-TCA
- Plate 9 Mean Concentrations of TETRA

The information depicted on these plates is derived from the mean concentrations of selected volatile organic compounds from the NUS/FIT CLP sampling rounds (Appendix G; Table 6) as well as from data collected by other consultants at the W.R. Grace, Wildwood Conservation Corporation, and UniFirst sites and data collected by EPA and other consultants from the COE wells (S87-S89). Data from sources other than NUS/FIT can be found in Appendix C. Data limitations were discussed in Chapter 2.0. These data were collected at different times and at a variety of locations by several parties. As a result, the plates do not represent discrete contaminant distribution at a specific time, but rather a general or composite view of contamination over a period of time. These plates will be further discussed in the following sections.

5.2.1.1 Distribution of Volatile Organic Compounds in Overburden

The mean concentration of total volatile organic compounds detected in overburden from NUS/FIT CLP sampling rounds ranged from not detected (ND) to 317,000 parts per billion (ppb) (Appendix G; Table 6). The highest mean total concentrations of volatile organic compounds were detected at wells S78S

(109,356 ppb), BSW6, (124,684 ppb), BSSW6 (317,000 ppb), GW3S (3,069 ppb), S71M (1,907 ppb), and S75S (4,702 ppb) and BW5 (2,900 ppb). Volatile organic contaminants identified were distributed predominantly in the northeastern and southwestern portions of the study area and at wells S71 and S75 in the northwest and north, respectively. Except for location S75 in the northwestern corner of the study area, volatile organic contaminants were not detected (ND) or were detected at low levels (<50 ppb) in the northern and western portions of the study area. Upgradient of the study area at wells OW-7, OW-8, OW-19, OW-19A, OW-20 and OW-20A, volatile organic distribution ranged from not detected (ND) to 10 ppb total volatile organic compounds. Volatile organic contaminants were also detected south of the study area at location S11 at 276 ppb (total volatile organic compounds). CLP results from the NUS/FIT wells agreed closely with the screening results of these wells. CLP analytical data are similar to the E & E analytical results and the NUS/FIT analytical results from the July, 1984 sampling round.

The volatile organic compounds detected most frequently were TCE; trans-1,2-DCE; 1,1,1-TCA; and TETRA; which accounted for approximately 75% to 90% of total volatile organic contamination detected in each groundwater sample. The mean concentration of TCE; trans-1,2-DCE; 1,1,1-TCA; and TETRA from the April, May, and June, 1985 NUS/FIT CLP sampling rounds are presented in Appendix G (Table 6). The highest mean concentrations of TCE in overburden were detected at wells BSSW6 (310,000 ppb), BSW6 (116,667 ppb), S78S (80,037 ppb), BW5 (2,900), and GW3S (1,003 ppb). The overburden distribution of TCE is predominantly in the northeastern and southwestern portions of the study area. Overburden concentrations of trans-1,2-DCE were distributed principally in the northeastern and southwestern portions of the study area with the highest mean concentrations detected at wells GW3S (1,955 ppb) and BSW2 (1,510 ppb). At most of the well locations in the southwestern portion of the study area, trans-1,2-DCE was detected at mean concentrations less than 50 ppb. The overburden distribution of 1,1,1-TCA was also predominantly in the northeastern and southwestern portions of the study area with the highest mean concentrations detected at BSW6 (4,667 ppb), S81S (183 ppb), and S71M (111 ppb). The highest mean concentrations

of TETRA in overburden were detected at S71M (1,700 ppb) and S81S (838 ppb) in the northern portion of the study area and at S78S (26,677 ppb) in the southwestern portion of the study area.

Elevated concentrations of volatile organic compounds were also detected at well S75S, but consisted of different compounds than those detected elsewhere in the study area. The mean concentrations of the compounds detected were: benzene (3,125 ppb), ethyl benzene (253 ppb), toluene (433 ppb), styrene (198), and total xylene (693 ppb).

The distribution of total volatile organic compounds; TCE; trans-1,2-DCE; 1,1,1-TCA; and TETRA are depicted in Plates 5 through 9, respectively. The highest concentrations of total volatile organic groundwater contamination in overburden were found in the northeastern portion of the study area at the W.R. Grace facility, at well S71 on UniFirst property, at well S75 on Weyerhaeuser property, and in the southwestern portion of the study area on the Wildwood Conservation Corporation property (Plate 5). Concentrations generally decreased from outlying areas of high levels of contamination inwards towards the center of the study area. Concentrations decreased to low or background levels beyond the study area. TCE and trans-1,2-DCE were detected at high concentrations (>1,000 ppb) in the northeastern portion of the study area at well locations GW3, GW14, GW15, GW12, and GW28 and in the southwestern portion of the study area at wells BSW6, BSSW6, BSW9, and BW9 (Plates 6 and 7). 1,1,1-TCA was detected in highest concentration in the southwestern portion of the study area at well BSW6 (4,667 ppb) and was detected in lower concentrations (<100 ppb) in the northern and northeastern portions of the study area (Plate 8). TETRA was detected in high concentrations at well S71 (1,700 ppb) in the northern portion of the study area and at well S78 (26,677 ppb) in the southwestern portion of the study area (Plate 9).

5.2.1.2 Distribution of Volatile Organic Compounds in Bedrock

The highest mean concentrations of total volatile organic compounds detected in bedrock groundwater from the NUS/FIT CLP sampling rounds were in the northern

and northeastern portions of the study area at wells GW3D (5,567 ppb), GW3DB (3,642 ppb), S71D (2,677 ppb), GO1DB (1,938 ppb), GW4D (1,700 ppb) and GW12D (1,633 ppb) (Appendix G, Table 6). Trace (<50 ppb) or no volatile organic contaminants were detected in bedrock wells located in the northwestern and western portion of the study except at well location S75. No volatile organic compounds were detected at the one bedrock location (S78D) in the southwestern portion of the study area. TCE and trans-1,2-DCE were detected predominantly in the northeastern portion of the study area with the highest mean concentrations detected at wells GW3D (2,433 ppb and 2,875 ppb, respectively) and GW3DB (2,100 ppb and 1,423 ppb, respectively) (Appendix G; Table 6). The volatile organic contaminant 1,1,1-TCA was detected in bedrock in much lower concentrations, with the highest mean concentrations detected at wells S71D (145 ppb) and GO1DB (130 ppb) (Appendix G; Table 6). TETRA was detected in bedrock predominantly in the northern and northeastern portions of the study area with the highest mean concentrations detected at S71D (2,475 ppb), GO1D (900 ppb) and GO1DB (1,790 ppb) (Appendix G; Table 6).

The distribution of total volatile organic compounds in the bedrock aquifer is similar to the distribution in overburden. High concentrations (>1,000 ppb) of volatile organic compounds were found in the northeastern portion of the study area at the W.R. Grace facility; at well S71 on UniFirst property; and in the southwestern portion of the study area on the Wildwood Conservation Corporation property (Plate 5).

TCE was detected at highest mean concentrations at wells GW3 (2,200 ppb) and BW9 (3,600 ppb) in the northeastern and southwestern portions, respectively, of the study area (Plate 6). It was detected at low (<100 ppb) to moderate (<500 ppb) levels elsewhere. Trans-1,2-DCE was also detected at high levels (>1,000 ppb) in the northeast portion of the study area at well GW3 (1,423 ppb) as well as at wells GW28 (2,057 ppb), GW15 (11,330 ppb), and GW4 (1,345 ppb). It was found at low (<100 ppb) to trace levels elsewhere (<10 ppb) (Plate 7).

The volatile organic contaminant 1,1,1-TCA was detected at moderate (<500 ppb) levels at wells GO1 (260 ppb) and S71 (145 ppb) and low (<100 ppb) to trace (<10 ppb) levels elsewhere (Plate 8). High mean concentrations (>1,000 ppb) of TETRA were detected at wells GO1 (1,790 ppb) and S71 (2,475 ppb). Except for trace levels at well BW9, TETRA was found in groundwater primarily from wells located in the northern and northeastern portion of the study area (Plate 9).

5.2.2 Extractable Organic Analytical Results

Extractable organic compounds analyzed included Hazardous Substance List (HSL) acid and base/neutral extractable compounds, pesticides, and polychlorinated biphenyls (PCBs). A few additional organic (non-HSL) compounds (herbicides and pesticides) will be discussed in the Federal and State Drinking Water Results section (Section 5.2.4). CLP extractable organic analysis of groundwater was conducted only for the April, May, and June, 1985 sampling rounds. Few extractable organic contaminants were detected in the study area. In addition, extractable organic compounds were detected at relatively lower concentrations than were the volatile organic compounds. Extractable organic analytical results are presented in Appendix G (Tables 7, 8 and 9). The list of extractable compounds analyzed for is presented in Appendix D.

5.2.2.1 Distribution of Extractable Organic Compounds in Overburden

The extractable organic compounds detected in groundwater from overburden included the following compounds:

Acid and base/neutral extractables:

bis(2-ethylhexyl) phthalate	benzoic acid
phenol	fluoranthene
1,2-dichlorobenzene	acenaphthene
naphthalene	acenaphthylene
2-methylnaphthalene	phenanthrene

Pesticides/PCBs:

chlordan

Bis(2-ethylhexyl) phthalate was detected in a number of groundwater samples from locations throughout the study area, but no distribution pattern was evident. Bis(2-ethylhexyl) phthalate is utilized as a plasticizer in the chemical industry and is fairly ubiquitous in urban environments. It is a common contaminant of environmental samples introduced during sample collection or laboratory analysis through the use of plastic disposable gloves. For example, all bis(2-ethylhexyl) phthalate analytical results for June, 1985 groundwater samples were rejected after data review because bis(2-ethylhexyl) phthalate was detected in the laboratory and field blank samples.

The overburden distribution of the remaining extractable organic compounds was fairly distinct. The extractable organic compounds 1,2-dichlorobenzene; naphthalene; 2-methylnaphthalene; and benzoic acid were detected only in the southwestern portion of the study area at one or more of the well locations BW5, BSSW6, and S78S. Trace amounts of the pesticide chlordan were also detected at well BSSW6. Phenol was detected at trace concentrations in the center of the study area at wells S68M and S86M. Trace amounts of 1,2-dichlorobenzene were also detected at well S86M. Finally, a number of extractable compounds, classed as polynuclear aromatic hydrocarbons (PAHs), were detected at location S75S. These included: fluoranthrene, acenaphthene, naphthalene, acenaphthylene, phenanthrene, and 2-methylnaphthalene.

5.2.2.2 Distribution of Extractable Organic Compounds in Bedrock

Two extractable organic compounds (bis(2-ethylhexyl) phthalate and chrysene) were detected in groundwater collected from bedrock wells (Appendix G, Tables 7, 8 and 9). No pattern of distribution of bis(2-ethylhexyl) phthalate was apparent. It was detected sporadically throughout the study area, but was also rejected from a number of samples due to blank contamination. Chrysene was detected at trace concentrations at S71D in the June, 1985 sampling round, however, it was not detected at this location in April, 1985.

5.2.3 Inorganic Analytical Results

The following section presents results of analyses of groundwater for HSL inorganics. Eleven HSL inorganic elements (arsenic, barium, cadmium, chromium, lead, mercury, nitrogen, selenium, silver, fluorine, and sodium) were also analyzed for under the Federal and State Drinking Water Quality standards discussed in section 5.2.4.2.

All HSL inorganic elements, excluding antimony (Sb) and selenium (Se), were detected in groundwater. No distribution pattern of inorganic elements was evident. The concentrations of each element were comparable in the overburden and bedrock aquifers except for the higher concentrations of calcium, magnesium, manganese, and chromium detected in the overburden aquifer. Inorganic analytical results from the April, May, and June, 1985 sampling rounds are presented in Appendix G; Tables 10, 11, and 12, respectively. Table 13 (Appendix G) summarizes the distribution of each element in the overburden and bedrock aquifers. Table 14 (Appendix G) summarizes the occurrences of each element. The elements can be divided into two groups: those found infrequently and at lower concentrations (<500 ppb), and those found frequently and at higher concentrations (6,000 to 150,000 ppb). The two groups are comprised of the following elements:

<u>Detected Infrequently</u>	<u>Detected Frequently</u>
Antimony (Sb)	Aluminum (Al)
Arsenic (As)	Calcium (Ca)
Barium (Ba)	Iron (Fe)
Beryllium (Be)	Magnesium (Mg)
Cadmium (Cd)	Manganese (Mn)
Chromium (Cr)	Potassium (K)
Cobalt (Co)	Sodium (Na)
Copper (Cu)	
Lead (Pb)	

Mercury (Hg)
Nickel (Ni)
Selenium (Se)
Silver (Ag)
Thallium (Tl)
Tin (Sn)
Vanadium (V)
Zinc (Zn)

All elements could at least be partially attributed to natural sources as they are constituents of either the bedrock or overburden. Common constituents of the bedrock found at this site are: Al, Ca, Fe, Mg, Mn, K, and Na (Smith and Hon, 1984, and Huang, 1962). These elements comprise the group of elements that were detected frequently and in higher concentrations. The source of the elements detected infrequently and in lower concentrations could be the soils present at the site. None of the elements were detected in sufficiently elevated concentrations or demonstrated a localized pattern of distribution that would indicate disposal of metals. The concentration of elements detected in regional soils is presented in Table 16 (Appendix G).

The concentrations in the study area of Ca, Fe, and Mg were higher than the concentrations of these elements in groundwater elsewhere in the drainage basin. The concentration of elements in groundwater from available published literature is presented in Table 15 (Appendix G). A contributing factor to the levels of Ca as well as to the levels detected of Na and Al could be the use of a bentonite/cement grout seal in construction of the NUS/FIT monitoring wells. A similar grout mixture was also utilized by GeoEnvironmental Consultants in construction of the W.R. Grace monitoring wells as documented by direct observations by NUS/FIT staff. Bentonite could be a source of aluminum and sodium (Huang 1969, Hurlbut 1971) while Portland cement could be a source of aluminum and calcium (Bates, 1969). High concentrations of Fe and Mn have been described by the City of Woburn in the drinking water from Wells G & H when the wells were in use (Section 2.0). Both Fe and Mn were detected at concentrations greater than their regulatory levels which are primarily based on the aesthetic qualities of taste and odor.

Only Cr, Fe, and Mn were detected at concentrations greater than their federally regulated levels listed in Table 3-7. The remaining elements with associated regulatory levels were not detected at concentrations greater than their federal or state regulated levels. Specific elements and the various regulatory levels are detailed below.

The inorganic elements As, Ba, Cd, Pb, Hg, and Ag were not detected at concentrations greater than the National Interim Drinking Water Regulations Maximum Contaminant Levels (MCLs) listed in Table 3-7. The MCLs are the acceptable levels of specified parameters in drinking water assuming a daily intake of two liters of water and a lifetime exposure. Chromium (Cr) was detected at concentration greater than the MCLs in four samples, but, for the most part, was not detected or detected below the MCLs. Sodium (Na) was detected at concentrations significantly greater than the advisory level of 20 mg/l. Iron (Fe) and manganese (Mn), were detected at concentrations greater than the National Secondary Drinking Water Regulations Maximum Contaminant Levels (SMCLs). The SMCLs are based primarily on the aesthetic drinking water qualities of taste and odor. Zinc (Zn) and copper (Cu) was detected below the SMCLs. The remaining elements detected in groundwater do not have regulatory levels assigned. These include: Be, Co, Ni, and V detected in relatively low concentrations (<140 ppb) and Al, Ca, Mg, and K detected in relatively higher concentrations (2,000 to 150,000 ppb).

5.2.3.1 Distribution of Inorganic Contaminants in Overburden

Higher concentrations of Ca, Mg, Mn, and Cr were detected in the overburden aquifer than the bedrock aquifer (Appendix G; Table 13). The concentrations of Cu, K, Mn, and Na detected in overburden are comparable to concentrations detected in groundwater elsewhere in the surrounding drainage basins (Appendix G; Table 15). The concentrations of Ca, Fe, and Mg are higher than concentrations detected in groundwater elsewhere in the surrounding drainage basins (Appendix G; Table 15). The range of concentrations detected in the overburden aquifer are

presented in Table 13 (Appendix G). Typical ranges for the elements in groundwater from the eastern Massachusetts drainage basins including the Aberjona and Mystic Rivers are presented in Table 15 (Appendix G). A contributing factor to the levels of calcium and sodium as well as to the levels detected of aluminum could be the use of a bentonite/cement grout seal in construction of the NUS/FIT monitoring wells as described earlier. Higher concentrations of Fe and Mn have been described by the City of Woburn in the drinking water from Wells G & H when the wells were in use (Section 2.0). Both iron and manganese were detected in the overburden at concentrations greater than the SMCLs which are primarily based on the aesthetic qualities of taste and odor. Chromium (Cr) was detected at concentrations greater than the MCLs in three out of twenty-seven samples. Sodium (Na) was also detected in most samples in overburden at concentrations greater than its advisory level. Iron (Fe) and manganese (Mn) were detected in most samples from the overburden aquifer at concentrations greater than the SMCLs.

5.2.3.2 Distribution of Inorganic Contaminants in Bedrock

The concentrations of Cu, K, Mg, and Na detected in bedrock were similar to level found in groundwater elsewhere in the surrounding drainage basins (Appendix G; Table 15). Calcium (Ca) and iron (Fe) were detected at higher concentrations than the concentrations detected in groundwater elsewhere in the surrounding drainage basins. A contributing factor to the levels of calcium as well as to the detected levels of aluminum and sodium could be the use of a bentonite/cement grout seal in construction of the NUS/FIT and GeoEnvironmental monitoring wells as described earlier. As in the overburden aquifer, iron and manganese were detected at concentrations greater than the SMCLs, which are primarily based on the aesthetic qualities of taste and odor. Magnesium (Mg), manganese (Mn), and sodium (Na) were detected at lower concentrations in the bedrock aquifer than in the overburden aquifer. Aluminum, (Al) calcium (Ca), iron (Fe), and potassium (K) were detected at comparable levels in both aquifers.

As in the overburden, sodium (Na) was detected in most samples at concentrations greater than its advisory level. No other elements were detected in the bedrock

aquifer greater than the MCLs. Iron (Fe) and manganese (Mn) were detected in most samples from the bedrock aquifer at concentrations greater than the SMCLs, reflecting again the pattern in the overburden.

5.2.4 Federal and State Drinking Water Quality Results

In order to meet the data needs of the Feasibility Study, a total of 32 groundwater samples were collected during the months of April and June, 1985 to be analyzed for Federal and State Drinking Water Quality Standards (Table 3-7). These were incorporated into the overall sampling effort when logistically feasible. Sampling locations outside of the study area (North Woburn) will be discussed in a separate section from the study area results. Drinking water quality parameters included: inorganic elements, general water quality chemistry (pH, color, chloride, sulfate, etc.), organic herbicides and pesticides, trihalomethanes (THMs), and microbiological analyses.

The inorganic elements analyzed for in these samples were As, Ba, Cd, Cr, Pb, Hg, nitrate, Se, Ag, fluoride, and Na. The organic herbicides and pesticides were endrin; lindane; methoxychlor; toxaphene; 2,4-D; and 2,4,5-TP (silvex). Trihalomethanes include: chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

The results for the inorganic elements that are part of the Drinking Water Quality Standards were consistent with the CLP inorganic analytical results (Appendix G; Tables 17 and 18). Analysis for general water quality criteria (pH, color, chloride, etc.) and microbiological parameters will primarily be utilized in the Feasibility Study to evaluate potential groundwater treatment methodologies (Appendix G; Tables 19, 20 and 21). The parameters pH, nitrate, sulfate, chloride, and total dissolved solids were generally within National Drinking Water Regulations Secondary Maximum Contaminant Levels (SMCLs). A number of values of total dissolved solids were above the SMCLs and were likely the result of silt present in the monitoring well. The results of microbiological analyses were within state

requirements with few total or fecal coliform bacteria being found. The pesticides and herbicides that are part of the Drinking Water Quality Standards were not detected in any samples (Appendix G; Table 22). Chloroform and bromoform, both trihalomethanes, were detected in only six samples from five groundwater sampling locations (Appendix G; Tables 3, 4, and 5).

5.2.4.1 Federal and State Drinking Water Quality Results in Overburden

The following section discusses only those results from the study area. Samples collected from outside the study area (North Woburn) will be discussed in a later section.

Chromium (Cr) was detected at concentrations greater than the MCL north of Wells G & H at sample location S73S, but was not detected or detected below the MCL elsewhere. Mercury (Hg) was detected at concentrations ten to twenty times greater than the MCL in wells S64S and S64M in June. Mercury was not detected previously in the HSL samples at location S64. Arsenic (As) was detected slightly above the MCL at location S73S in one sample, but was not detected in the duplicate of that sample. It was not detected or detected below the MCL elsewhere. All samples, with the exception of sample S84M, contained substantial amounts of sodium above the advisory level of 20 mg/l. Barium (Ba), cadmium (Cd), lead (pb), selenium (Se), and silver (Ag) were not detected at concentrations greater than the MCLs.

Iron (Fe) and manganese (Mn) concentrations exceeded the SMCLs for most samples collected in the overburden. The remaining elements detected in the overburden do not have regulatory levels assigned, but were detected in relatively low concentrations (<340 ppb) for Sb, Be, Co, Tl, Sn, and V; and in relatively higher concentrations (1,000 to 100,000 ppb) for Al, Ca, Mg, Ni, and K.

No drinking water quality pesticides or herbicides (endrin; lindane; methoxychlor; toxaphene; 2,4-D; and 2,4,5-TP (Silvex)) were detected in the overburden aquifer (Appendix G; Table 22). The trihalomethane compound chloroform was detected at

well BSW6 (2,800 to 3,000 ppb) in April, at wells S81M (17 ppb) and S85M (13 ppb) in May, and at well S10 (1 ppb) in June (Appendix G; Tables 3, 4, and 5). However, in replicate samples from other sampling rounds, no chloroform was detected at wells S81M, S85M, and S10. Well BSW6 was sampled only in April and therefore replicate samples are not available.

5.2.4.2 Federal and State Drinking Water Quality Results in Bedrock

The following section discusses only those results from the study area. Samples collected from outside the study area (North Woburn) will be discussed in Section 5.2.4.3.

Cadmium (Cd) was the only element detected in the bedrock aquifer which exceeded the MCLs. At location S76D, cadmium (Cd) was detected at 37 ppb (Appendix G, Table 18). Sodium (Na) was detected at a concentration slightly greater than its advisory level at well S74D. Sodium was detected below its advisory level elsewhere. Iron (Fe) and manganese (Mn) were detected in both bedrock wells S76D and S84D at concentrations greater than the SMCLs. Other inorganic contaminants, such as Cu and Zn, were not detected above the SMCLs in the groundwater samples.

No drinking water quality pesticides or herbicides (endrin; lindane; methoxychlor; toxaphene; 2,4-D; and 2,4,5-TP (Silvex)) were detected in the bedrock aquifer (Appendix G; Table 22). The trihalomethane bromoform was detected at well S71D in April, but was not detected at this location in May and June. No other THMs were detected in the bedrock aquifer.

5.2.4.3 Federal and State Drinking Water Quality Results for North Woburn

As noted in Section 2.6, the distribution of contamination in North Woburn is of interest due to the location of another NPL site, Industriplex, in that area. Contaminated groundwater from the Industriplex site as well as other potential sources upgradient may eventually impact Wells G & H. Six wells located

upgradient of the NUS/FIT study area (OW-7, OW-8, OW-19, OW-19A, OW-20, OW-20A) were sampled during April 1985 for federal and state Drinking Water Quality Standards.

Arsenic (As), barium (Ba), Calcium (Ca), sodium (Na), mercury (Hg), and zinc (Zn) were detected in groundwater samples collected from North Woburn (Appendix G, Table 17). At a number of wells, arsenic (As) was detected in the groundwater samples at levels greater than the MCL and sodium (Na) was detected at levels greater than its advisory level. At well location OW-7 and OW-20A, arsenic was detected at concentrations of 108 ppb and 342 ppb respectively, exceeding the 50 ppb established MCL. Sodium (Na) was detected at concentrations of 22.9 to 131 ppm in five of the six samples collected. Both elements, arsenic and sodium, have been detected in the groundwater collected at the Industriplex site by other consultants (Section 2.0).

5.3 Surface Water Results

Surface water samples were collected during the initial sampling round for NUS/FIT volatile screening in July, 1984 (Table 3-1) and during the April, May, and June, 1985 sampling rounds for CLP analysis (Tables 3-3, 3-4, and 3-5). The screening results from the initial sampling round are presented in Table 23 (Appendix G). The surface water results for CLP volatiles and metals are presented in Tables 24 and 25, respectively (Appendix G). The surface water analyses for extractable organic compounds collected during the April, May, and June, 1985 sampling rounds are presented in Tables 7, 8, and 9, respectively (Appendix G).

The volatile organic compounds 1,1,1-TCA; TCE; trans-1,2-DCE; TETRA; and toluene were detected in surface water at concentrations ranging from not detected (ND) to 26 ppb. No extractable compounds (acid and base/neutral extractables, pesticides, or PCBs) were detected. A number of metals were detected at various concentrations. These included Al, Ba, Be, Cd, Ca, Cr, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, and Zn. These results are discussed in more detail in Section 5.3.3.

5.3.1 Volatile Organic Analytical Results

Trace amounts (<10 ppb) of TCE were detected in all three surface water samples and one of the sediment samples (SS-01) in the initial sampling round (Appendix G; Table 23). The sediment sample was taken from a location upstream of the study area. No other volatile organic compounds were detected in the initial sampling round.

Trace amounts (<10 ppb) of 1,1,1-TCA were detected at all surface water locations during the April, 1985 sampling round (Appendix G; Table 24). In addition, trace levels of toluene were detected at one downstream location (SW-02). No other volatile organic compounds were detected. During the May, 1985 sampling round, 1,1,1-TCA was again detected at most surface water locations both upstream and downstream (Plate 2). In addition, the volatile organic compounds trans-1,2-DCE; TCE; and TETRA were detected at low concentrations (4 to 25 ppb) at surface water location SW-03. This sample was collected from the center of the site from the western branch of the Aberjona River (Plate 2). No volatile organic compounds were detected in surface water from the June, 1985 sampling round.

5.3.2 Extractable Organic Analytical Results

Extractable organic compounds (base/neutral and acid extractable compounds, pesticides, and PCBs) were not detected in any of the surface water samples (Appendix G; Tables 7, 8, and 9).

5.3.3 Inorganic Analytical Results

The inorganic elements detected in surface water included: Al, Ba, Be, Cd, Ca, Cr, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, and Zn (Appendix G; Table 25). Aluminum (Al), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), nickel (Ni), and silver (Ag) were only detected in the upstream sample (SW-06). The inorganic elements not detected included: Sb, As, Co, Pb, Hg, Se, Tl, Sn and V.

Barium (Ba), cadmium (Cd), chromium (Cr), and silver (Ag) were detected at concentrations below the National Interim Primary Drinking Water Regulations (MCLs) (Table 3-6). Sodium (Na) was detected at concentrations nearly three times greater than its advisory level of 20 mg/l. Copper (Cu) and zinc (Zn) were detected at concentrations below the National Interim Drinking Water Regulations Secondary Maximum Contaminant Levels (SMCLs). The SMCLs are based on primarily aesthetic drinking water qualities such as taste and odor. Manganese (Mn) was detected at concentrations greater than the SMCLs and iron (Fe) was detected at or just above the SMCLs. The remaining elements (Al, Be, and Ni) were detected at low concentrations (<25 ppb), while Ca, Mg, and K were detected at relatively high concentrations (4,700 to 39,000 ppb).

6.0 CONCLUSIONS

The following section discusses the degree and extent of contamination existing in the Wells G & H study area. Contaminant pathways and mechanisms as well as a description of the groundwater plumes and areas of contamination are included. An identification of source areas is then presented, followed by a summary and recommendations.

6.1 Degree And Extent of Contamination

The following is a summary of the contamination of surface water and sediments, air, and groundwater detected at the site. Soil contamination will be addressed in Part II of the Remedial Investigation. The following section serves as a summary of analytical results and therefore does not reiterate all of the evidence to support the conclusions of the study.

● Surface Water and Sediment Contamination

The volatile organic compound 1,1,1-TCA was detected in both upstream and downstream surface water samples at concentrations ranging from not detected (ND) to 10 ppb in the April and May, 1985 NUS/FIT sampling rounds. During the May, 1985 sampling round, trans-1,2-DCE; TCE; and TETRA were also detected (3 to 26 ppb) at one surface water location in the center of site located on the western branch of the Aberjona River. In addition, trace levels of toluene (1 ppb) were detected at one downstream location during the April, 1985 sampling round. No volatile organic compounds were detected in surface water in the June, 1985 NUS/FIT CLP sampling round. Trace concentrations (<10 ppb) of TCE were detected by NUS/FIT analytical screening in one sediment sample collected upstream of the study area. No extractable organic compounds (acid and base/neutral extractables, pesticides and PCBs) were detected in surface water. The following inorganic elements were detected in surface water at varying concentrations: aluminum, barium, beryllium, cadmium, calcium, chromium, iron, magnesium, manganese, potassium, silver, sodium, and zinc.

During the investigation, levels of contamination in surface water varied from none detected (ND) to low levels (<26 ppb) of four different volatile organic compounds. The volatile organic compounds trans-1,2-DCE; TCE; and TETRA were only detected at one onsite location and, therefore, may indicate an onsite source. However, the most prevalent surface water contaminant, 1,1,1-TCA, was found at the same levels in both upstream and downstream samples.

● Air Contamination

The air route is not a major pathway of contaminant movement in the Wells G & H study area. Ambient air monitoring was conducted during all NUS/FIT field activities including installation of monitoring wells. No airborne volatile organic compounds were detected with the Foxboro Century Systems (OVA) Model 128 Organic Vapor Analyzer in any part of the study area. Surface water does not appear to be a significant pathway for volatile vapors as contaminant concentrations detected in surface water were relatively low.

Soil contamination could impact air quality by releases of volatile organic compounds, dispersion of dust or transport of soil by flooding of low lying areas. Soil contamination will be discussed in the contaminant source characterization and assessment document (Part II of the Remedial Investigation). However, no airborne volatile organic compounds were detected in areas of soil contamination unless those areas were physically disturbed (e.g., by test pit excavation).

● Groundwater Contamination

The most prevalent form of groundwater contamination present at the Wells G & H site was found to be volatile organic contamination. The most common volatile organic contaminants detected were: TCE; trans-1,2-DCE; 1,1,1-TCA; and TETRA. Volatile organic contaminants detected less frequently and generally in lower concentrations included: 1,1-dichloroethane; 1,1,2,2-tetrachloroethane; 1,2-dichloroethane; 1,1-dichloroethene; benzene; ethylbenzene; toluene; vinyl chloride; styrene; and xylene.

High levels of volatile organic compounds were detected primarily in the northeastern and southwestern portions of the study area. The most pervasive and highly concentrated volatile organic compounds in the northeastern portion of the study area are TCE and trans-1,2-DCE. TCE was also found in the southwestern portion of the site where this compound comprises the main contaminant constituent.

High levels (>1,000 ppb) of volatile organic contamination were also detected due north of Wells G & H at S71 and the northwest at S75. The contamination at well S71 was characterized by high concentrations of TETRA. Analytical samples drawn from S75 in the northwest portion of the site exhibited high concentrations of volatile organic compounds which are constituents of petroleum. These contaminants include benzene, ethylbenzene, toluene, and xylene.

The few extractable organic compounds detected were, for the most part, limited to the southwestern portion of the study area and well location S75 in the northeastern corner of the study area and were detected in much lower concentrations than the volatile organic compounds. The extractable organic compounds 1,2-dichlorobenzene; naphthalene; 2-methylnaphthalene; benzoic acid; and the pesticide chlordane were detected only in the southwestern portion of the study area. A number of extractable compounds, classed as polynuclear aromatic hydrocarbons (PAHs) such as fluoranthene and acenaphthene were detected at well location S75. These compounds are also constituents of petroleum products. All Hazardous Substance List (HSL) inorganic elements, with the exception of antimony and selenium, were detected in groundwater at varying concentrations. A pattern of distribution of elements throughout the study area was not demonstrated.

Based on the history of the Wells G & H study area and the analytical and hydrogeologic data presented in this report, the major pathway of concern for volatile organic contamination is groundwater. The following sections detail the distribution pattern of groundwater contamination in the study area and present

the supporting evidence for identifying groundwater contamination source areas. Prior to the discussion of groundwater contamination distribution, an overview of key groundwater transport mechanisms is presented.

6.1.1 Groundwater/Contamination Transport Mechanisms

This section presents a generalized discussion of the mechanisms that influence organic chemical solute (contaminant) transport in saturated groundwater environments. It is meant to familiarize the reader with terms used in the following sections. The mechanisms include:

- Advection
- Dispersion
- Transformation
- Sorption

The dominant factor governing the migration of a dissolved contaminants through a sand and gravel aquifer is advection. In the advection process, contaminants are transported by the bulk motion of flowing groundwater.

Dissolved contaminants spread as a result of molecular diffusion and mechanical mixing as they migrate with the groundwater. This process is referred to as dispersion. Dispersion and spreading during transport result in the dilution of contamination. The maximum contaminant concentrations would therefore diminish with increased distance from the source (MacKay et al., 1985)

As the contaminants flow through the groundwater, they might become degraded, or transformed into other compounds. This effect is accomplished through either chemical or biological processes. Hydrolysis and oxidation reactions are the principal causes of chemical degradation of contaminants. Most chemical reactions occurring in the groundwater are likely to be slow when compared with biological transformations resulting from the action of microorganisms (MacKay et al., 1985).

Certain contaminants can be biologically transformed by microorganisms attached to solid surfaces in the aquifer, for example, biotransformation of groundwater contaminants such as TETRA; TCE; or 1,1,1-TCA can result in the formation of vinyl chloride (MacKay et al., 1985).

Some dissolved contaminants may interact with aquifer solids encountered along the flow path through adsorption. The higher the fraction of contaminant sorbed, the more retarded the transport. The retardation factors for the primary contaminants found at the Wells G & H site (TETRA; TCE; 1,1,1-TCA) are expected to fall in the ranges from 1 to 10 (MacKay et al., 1985) and would therefore travel at 10 percent to 100 percent of the velocity of groundwater. Retardation of contaminant flow due to sorption in the overburden aquifer is likely minimal at the Wells G & H site due to the nature of the geologic deposits (excluding peat deposits).

6.1.2 Distribution Pattern of Groundwater Contamination

The evaluation of analytical data in conjunction with groundwater flow directions and contaminant flow mechanisms suggests the existence of two major plumes of groundwater contamination (the Northeastern Plume and the Northern Plume) and two other areas of major groundwater contamination (the Wildwood Conservation Corporation site and well location S75 in the northwest corner of the study area). A plume of contamination is defined as an area of groundwater contamination that can be described horizontally and vertically, and can be traced continuously over a distance. Discussed below is the evidence to support the delineation of these plumes and areas of groundwater contamination.

6.1.2.1 Northeast Volatile Organic Contaminant Plume

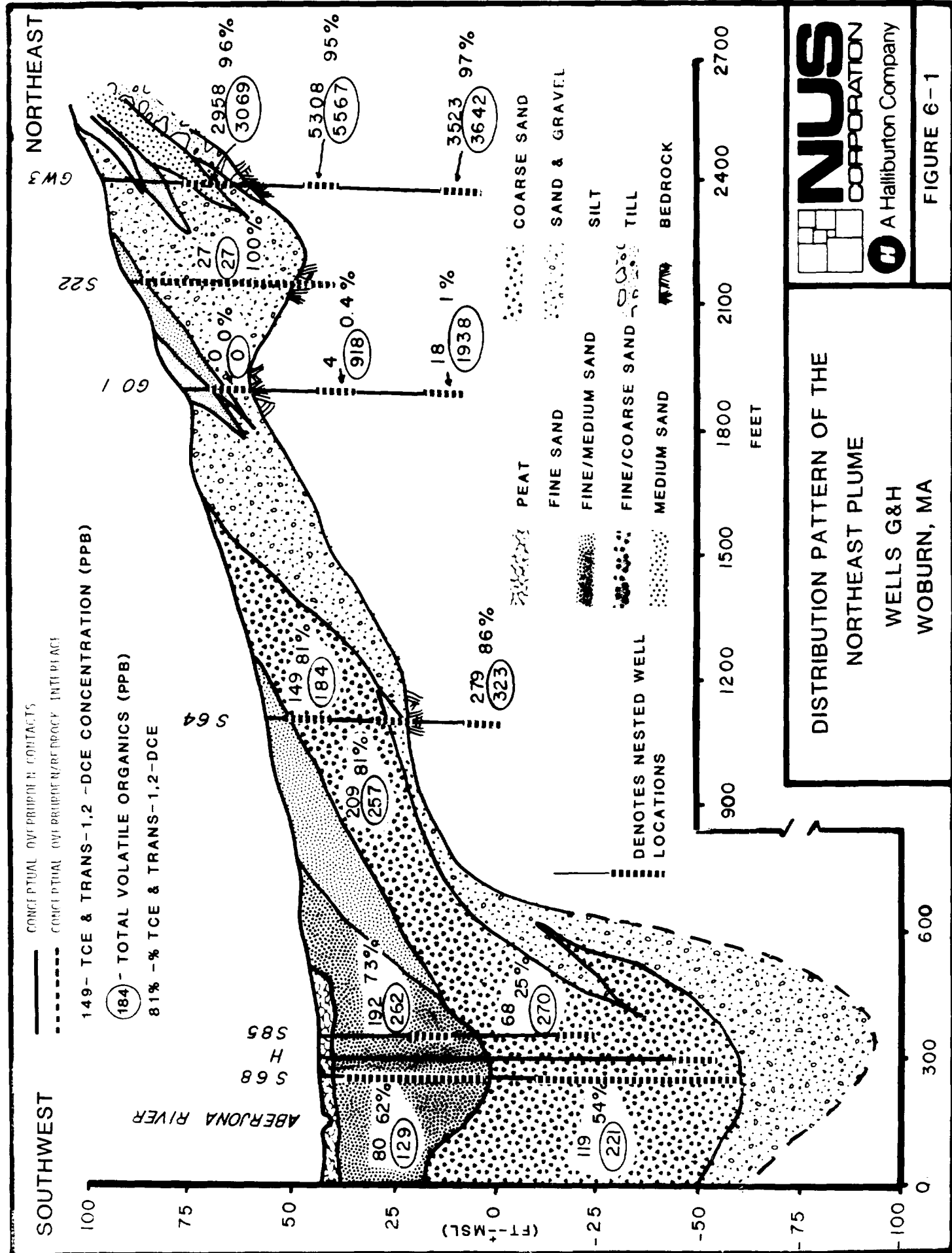
NUS/FIT has identified horizontal and vertical distribution of volatile organic contaminants that is indicative of a plume of overburden and bedrock groundwater contamination that extends from Wells G & H northeast to the W.R. Grace property.

This plume consists primarily of chlorinated solvents and is characterized by high percentages of TCE and trans-1,2-DCE with respect to the remaining constituents. Other constituents include: 1,1,1-TCA; TETRA; 1,1-dichloroethene and vinyl chloride. Table 6 (Appendix G) lists the mean concentrations of volatile organic compounds detected in the Wells G & H study area. The highest concentrations of TCE and trans-1,2-DCE in the northeastern portion of the study area were detected in samples from the W.R. Grace monitoring wells. Mean concentrations of TCE are as high as 1,003 ppb (GW3S) and 2,433 ppb (GW3D) in overburden and shallow bedrock, respectively. Mean concentrations of trans-1,2-DCE are as high as 1,955 ppb (GW3S) and 2,875 ppb (GW3D) in overburden and shallow bedrock, respectively.

Water level measurements from monitoring wells in the area indicate the predominant groundwater flow direction to be from the northeast to the southwest. The wells located northeast of well GW3 are considered to be upgradient and those wells to the southwest downgradient.

Samples collected from the upgradient wells (GW1 and GW8) did not contain TCE and trans-1,2-DCE contamination. Samples collected from downgradient wells S22, S21, S63 and S64 contained concentrations of TCE and trans-1,2-DCE ranging from 27 to 350 ppb (Appendix G: Table 6). Figure 6-1 depicts the vertical distribution of TCE and trans-1,2-DCE in overburden and shallow bedrock. The plume migrates to the southwest from the vicinity of well GW3 flowing beneath West Cummings Park to Wells G & H. The mean concentrations decrease downgradient. The same compounds are detected with the main constituents (TCE and trans-1,2-DCE) comprising 25 percent to 86 percent of the total volatile organic contaminant concentrations.

The volatile organic contamination detected in the two bedrock wells, located at the W.R. Grace monitoring well cluster GO1, does not reflect the same chemical pattern as the other wells in the northeastern portion of the study area. A lower percentage of TCE and trans-1,2-DCE is detected (0 to 1.0% of the total volatile



DISTRIBUTION PATTERN OF THE
NORTHEAST PLUME
WELLS G&H
WOBBURN, MA

FIGURE 6-1

organic contamination) and a higher percentage of TETRA is detected (92 to 98% of the total volatile organic contamination). This pattern is similar to that which characterizes the northern plume. A description of the northern plume and a discussion of the relationship of well location GO1 to this plume is included in the following section.

6.1.2.2 Northern Volatile Organic Contaminant Plume

A second plume was identified by NUS/FIT in the north/central portion of the site, based on the horizontal and vertical distribution of volatile organic contaminants. The plume exists between Wells G & H and the UniFirst Corporation property. The Northern Plume can be differentiated from the Northeastern Plume based on differences in the amounts of its chemical components. The Northern Plume is characterized by a predominance of tetrachloroethene (TETRA) which comprises as much as 100% (well S81M) of the total volatile organic contaminant concentrations. A secondary constituent is 1,1,1-trichloroethane (1,1,1-TCA), with minor percentages of trichloroethene (TCE) and trans-1,2-dichloroethene (trans-1,2-DCE). Mean TETRA concentrations of 1,700 ppb and 2,475 ppb were detected in groundwater drawn from overburden and bedrock at S71, respectively (Figure 6-2). Water level measurements collected from monitoring wells in the area indicate the predominant groundwater flow direction is from the east-northeast to west-southwest. Groundwater flow direction beneath the UniFirst Corporation property to the southwest becoming increasingly southerly as it migrates downgradient toward Wells G & H and the Aberjona River. Samples collected from monitoring wells IUS-1, IUS-2, IUS-3 upgradient and north from S71 contained no detectable volatile organic contamination. Vertical distribution of TETRA in overburden and bedrock is depicted in Figure 6-2. Mean concentrations of contaminants decrease downgradient from well location S71. The percentage of TETRA as compared to total volatile organic contaminant concentrations decreases from a range of 89 to 100% at well locations S71 and S81 to a range of 23 to 62% at well locations S82 and S85. The percentage of TCE and trans-1,2-DCE compared to total volatile organic contaminant concentrations increases from

NORTHEAST

SOUTHWEST

KEY:

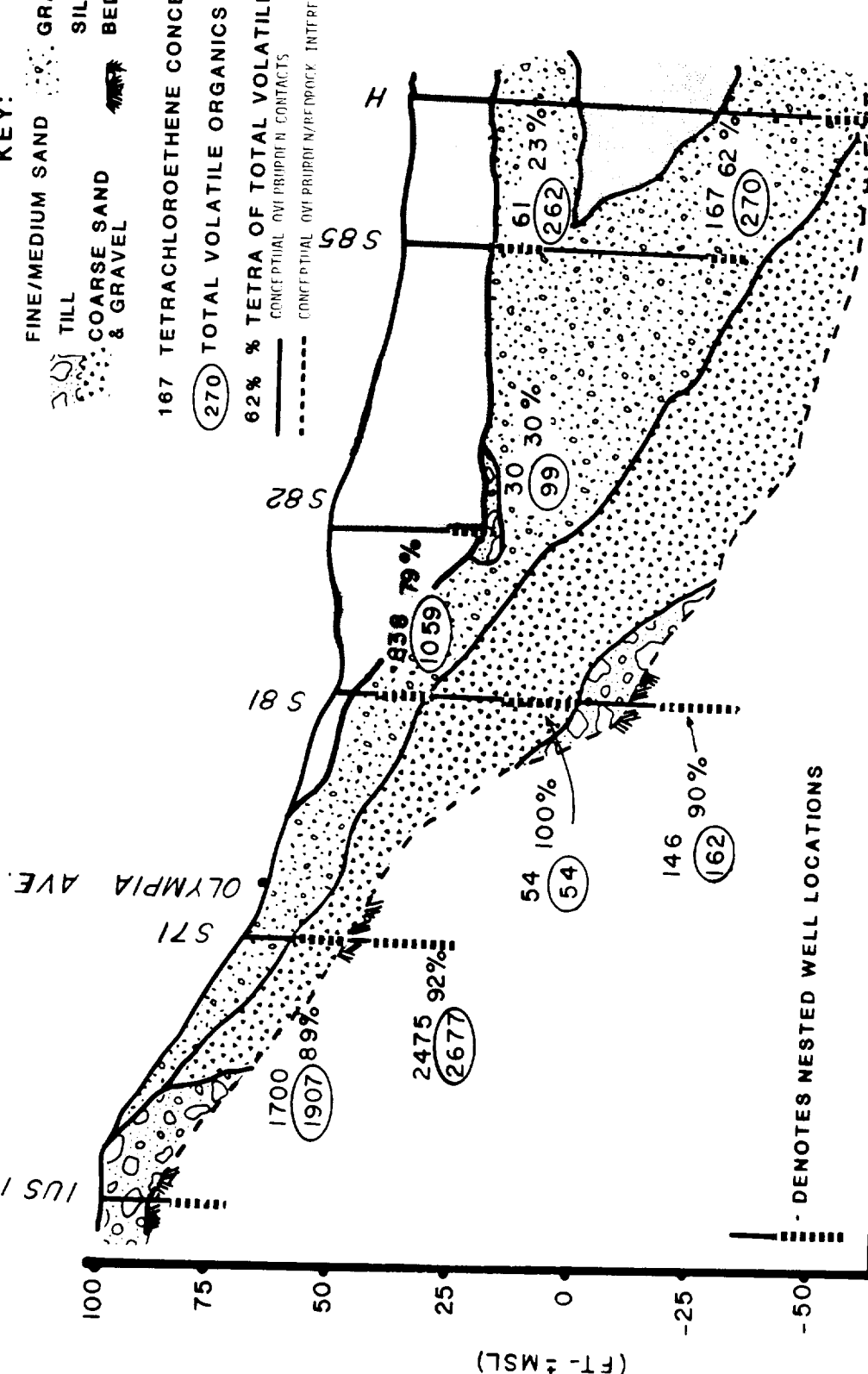
FINE/MEDIUM SAND
TILL
GRAVEL
SILT
BEDROCK
COARSE SAND & GRAVEL

167 TETRACHLOROETHENE CONCENTRATION (PPB)

(270) TOTAL VOLATILE ORGANICS

62% % TETRA OF TOTAL VOLATILE ORGANICS

CONCEPTUAL OVI PLUME N CONTACTS
CONCEPTUAL OVI PLUME N/BE DPOCK INTERFACE



(FEET)

DISTRIBUTION PATTERN OF THE

NORTHERN PLUME

WELLS G&H

WOBURN, MA



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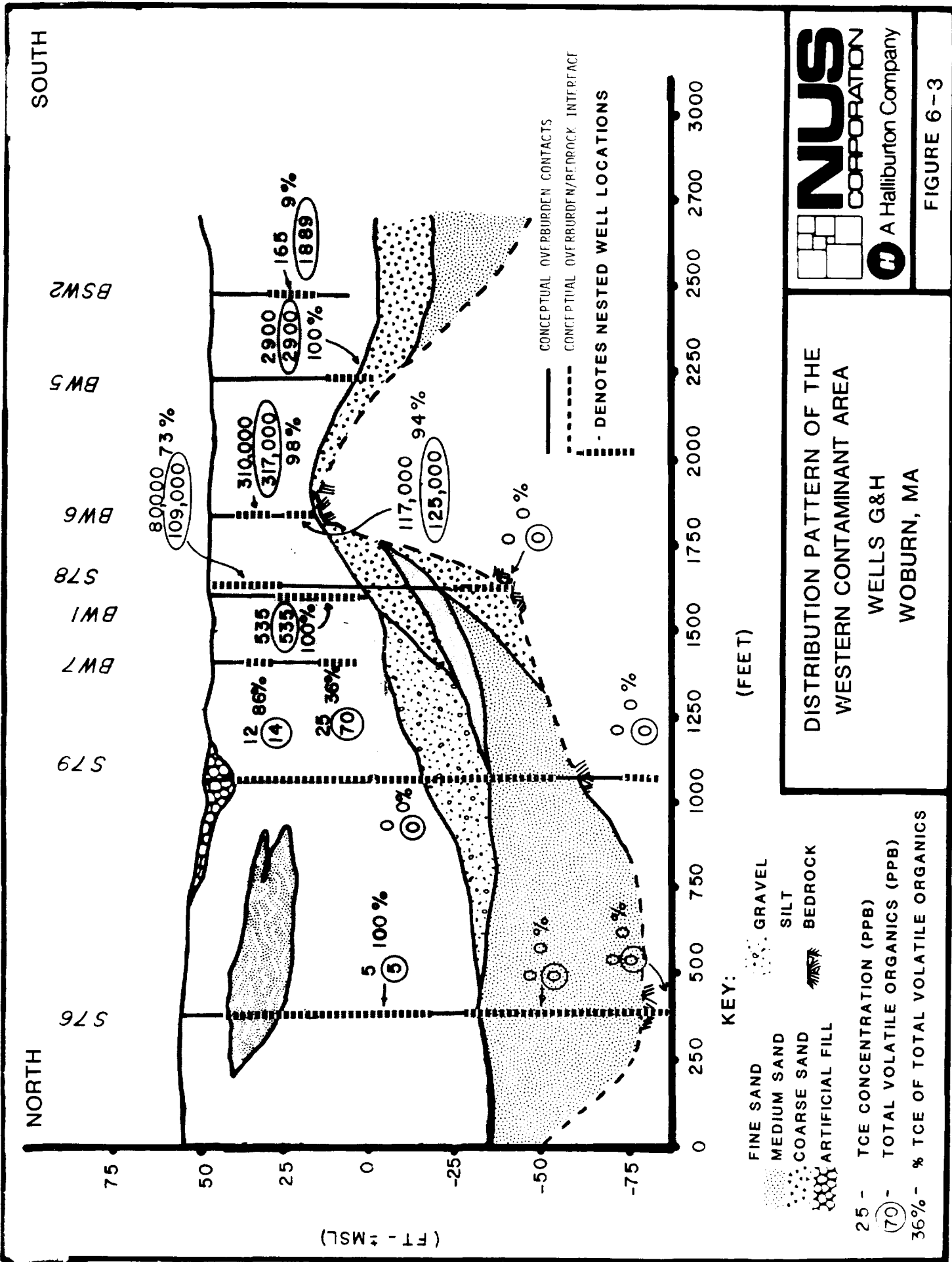
FIGURE 6-2

a range of 0 to 5% at well locations S71 and S81 to a range of 25 to 73% at well locations S82 and S85. This increase in TCE and trans-1,2-DCE percentage and decrease in TETRA percentage suggests that well locations S82 and S85 were installed within the zone of convergence of the Northern and Northeastern plumes.

It was noted in the previous section that the constituent percentages of contaminants characteristic of the Northern Plume were detected in samples drawn from bedrock wells G01D and G01DB. These wells are located approximately 600 feet south-southeast of well location S71 where the highest contaminant concentrations were detected. Well G01 is located in the proximity of a destroyed bedrock production well previously used by Johnson Brothers, Inc., bedrock production well (Section 4.3) was reported to be capable of yielding 110 gallons per minute. This pumping rate indicates that the well drew from a substantial system of interconnected fractures in the bedrock. Fracture analysis conducted in the study area indicates a moderately preferred orientation of joints striking between N63°W and N90°W and dipping from 10° to 40° SW (E & E, 1982). This data suggests that well G01D and G01DB may intercept the Northern Plume moving downdip in the bedrock fracture plane.

6.1.2.3 Western Volatile Organic Contaminant Area

An area of volatile organic contamination of groundwater exists in the western and southwestern portion of the study area. The contamination consists primarily of high concentrations of the chlorinated solvent TCE detected at a number of wells, with high concentrations of 1,1,1-TCA; trans-1,2-DCE; and TETRA detected at only a few wells. The highest mean concentrations of TCE were detected at well S78S (80,000 ppb), well BSSW6 (310,000 ppb) and well BSW6 (117,000 ppb) (Figure 6-3). High levels of 1,1,1-TCA were also detected at well locations BSW6 (4,667 ppb). High levels of TETRA were only detected at well S78S (26,677 ppb) (Appendix G: Table 6). No volatile organic contaminants were detected in the NUS/FIT bedrock well S78D or the upgradient well S79. However, volatile organic compounds were detected in bedrock wells (BW8, 9, 10 and 13) by other consultants (Plate 5). This contamination consisted primarily of TCE ranging from 170 to 3,600 ppb (Appendix C: Table 4). The contaminated area is concentrated in the



shallow overburden as demonstrated by the high concentrations detected at S78S (109,000 ppb) and BSSW6 (317,000 ppb) (Figure 6-3). Extractable organic compounds were detected in lower concentrations and less frequently. The compounds 1,2-dichlorobenzene; naphthalene; 2-methylnaphthalene; and benzoic acid were detected at well locations BW5, BSSW6, and S78S. Trace amounts of the pesticide chlordane was also detected at well BSSW6 (Section 5.2.2).

The John J. Riley Tannery Production Well no. 2 (S46) is located within the area of groundwater contamination on the Wildwood Conservation Corporation property. This production well is capable of pumping 750 gallons per minute but is pumped according to work demand typically 14 hours per day. It is approximately 50 feet deep and is screened in sands and gravel. Pumping of this well would influence groundwater and contaminant transport through the overburden near the well. The area affected would correlate to the production well's area of diversion. The hydrologic relationship between this area of groundwater contamination, the Aberjona River, and Wells G & H is unknown. An aquifer test that involved pumping Wells G & H at historical pumping rates and the measurement of water levels at a large number of well locations in study area was conducted by USGS (Section 2.7). The results of this aquifer test should provide insight into the relationship between pumping Wells G & H, the Aberjona River, and groundwater west of the river.

6.1.2.4 Northwestern Contaminant Area

The volatile organic compounds benzene, toluene, ethylbenzene, and xylene were detected at well S75 located on the Weyerhaeuser property (in the northwestern portion of the study area) and at wells located on the Juniper Development Group property (in the north-northwestern portion of the study area). In addition, a number of polynuclear aromatic hydrocarbons (PAHs) including fluoranthene, acenaphthene, naphthalene, acenaphthylene, phenanthrene, and 2-methyl-naphthalene were also detected in groundwater samples from well S75. This combination of contaminants was not detected in groundwater or surface water

elsewhere in the study area. These volatile organic and extractable organic (PAH) compounds are common constituents of gasoline. The highest concentrations of this contamination was detected in the shallow overburden well S75S (4,712 ppb). The concentrations decreased with depth to 230 ppb in the bedrock well S75D. Lower levels (170 to 750 ppb) were detected in wells located on the Juniper Development Group property. Gasoline is less dense than water and if spilled on the ground surface could migrate through the vadose zone to groundwater. The resultant plume of gasoline contamination would consist of an immiscible layer on top of the water and a dissolved portion in groundwater. Sparse data make description of the extent and characteristics of this plume difficult.

6.2 Sources of Contamination

NUS/FIT identified four areas of groundwater contamination within the study area. The following sections will present the evidence for identifying the source areas. The northeastern plume, characterized by a predominance of TCE and trans-1,2-DCE, emanates from the W.R. Grace property. The northern plume, characterized by a predominance of TETRA emanates from the UniFirst Corporation property. The western area of contamination, characterized by a predominance of trichloroethene and isolated part per million (ppm) concentrations of other volatile organic contaminants, emanates primarily from the Wildwood Conservation Corporation property. The source area of the gasoline contaminated groundwater detected at well S75 cannot be determined. Volatile organic groundwater contamination underlying the Juniper Development Group property may be due to prior site activities.

6.2.1 Northeastern Volatile Organic Contaminant Plume

NUS/FIT concludes that the northeastern plume emanates from the W.R. Grace property. The evidence supporting this conclusion is as follows:

- Onsite disposal of hazardous waste was demonstrated by the excavation and sampling of the contents of 55-gallon drums in the rear of the facility. A

number of volatile organic and extractable organic compounds were detected in the contents of the drums as well as in soils in the excavated area (Section 2.3). Further excavation of contaminated soils has been conducted and will be discussed in Part II of the Remedial Investigation.

- Groundwater underlying W.R. Grace property is contaminated primarily by chlorinated solvents with a high percentage of TCE (40 to 60%) with respect to the remaining constituents trans-1,2-DCE; 1,1,1-TCA; TETRA; 1,1-dichloroethene; and vinyl chloride. TCE was not detected in these proportions elsewhere in the north and the northeastern portions of the study area.
- Volatile organic groundwater contamination was not detected upgradient of the W.R. Grace property at well locations GW-1, GW-2, and GW-8.
- NUS/FIT has detected a continuous plume of volatile organic groundwater contamination that extends from the W.R. Grace property downgradient to Wells G & H. The highest concentrations detected were on the W.R. Grace property with mean concentrations as high as 1,003 ppb and 2,433 ppb in the overburden and shallow bedrock, respectively. Concentrations decrease with distance away from the W.R. Grace property and towards Wells G & H. This plume configuration is consistent with local groundwater flow patterns.

6.2.2 Northern Volatile Organic Contaminant Plume

NUS/FIT concludes that the northern plume emanates from the UniFirst Corporation property. The evidence supporting this conclusion is as follows:

- UniFirst used TETRA as a dry cleaning agent in its uniform service operations. It stored the solvent onsite in a 5,000 gallon above ground tank from 1977 to 1982. A spill, contained and cleaned up by UniFirst, was reported by the firm in 1979.

- Contamination detected in groundwater underlying the UniFirst Corporation property consisted of 89 to 92% TETRA with respect to the remaining constituents (1,1,1-TCA; TCE; trans-1,2-DCE).
- Volatile organic groundwater contamination was not detected upgradient and north of the property at well locations IUS-1, IUS-2, and IUS-3.
- NUS/FIT has detected a continuous plume of volatile organic contamination emanating from the UniFirst property and extending downgradient to Wells G & H and the Aberjona River.

6.2.3 Western Volatile Organic Contaminant Area

NUS/FIT concludes that the western area of groundwater contamination emanates primarily from the Wildwood Conservation Corporation property with possible additional sources of volatile organic groundwater contamination located north and south of the property. The evidence supporting this conclusion follows:

- Surface disposal of 55-gallon drums (now rusted), miscellaneous debris, and pesticide caps on the Wildwood Conservation Corporation property has been documented. Interpretation of aerial photography suggests that the Wildwood Conservation Corporation property may have been used for disposal of drums and/or tanks.
- Soil boring analytical data collected by Woodward-Clyde Consultants in 1983 demonstrated shallow soil contamination on the Wildwood Conservation Corporation property.
- Groundwater contamination has been detected at the Wildwood Conservation Corporation property consisting primarily of the chlorinated solvent TCE with localized high concentrations of 1,1,1-TCA; trans-1,2-DCE; and TETRA.

- Volatile organic groundwater contamination was not detected north and northwest of the property at well locations S79, S80, and S74.
- NUS/FIT identified an area of volatile organic groundwater contamination concentrated in shallow overburden extending from well location BW-7 to well location BSW-2.
- Volatile organic contamination of groundwater was also demonstrated south and downgradient of the property at well locations S83 and S77.

6.2.4 Northwestern Contaminant Area

NUS/FIT concludes that an area of gasoline contamination of unknown dimensions exists in the vicinity of well location S75 and is likely the result of a spill(s) or leaking underground storage tank(s). This contamination is characterized by the presence of volatile organic (benzene, toluene, ethylbenzene, xylene) and extractable organic (polynuclear aromatic hydrocarbons) compounds detected in groundwater at this location. These compounds are common constituents of gasoline. Additional groundwater contamination by benzene, toluene, ethylbenzene, and xylene underlies the Juniper Development Group property. It is also likely the result of a gasoline spill(s) or leaking underground storage tank(s).

This pattern of contamination was not detected elsewhere in the study area. Based on groundwater flow, the source of contamination at well S75 is believed to be northwest of well S75. Contamination of groundwater underlying the Juniper Development Group property may be due to site activities occurring before the current ownership.

6.3 Summary

NUS/FIT conducted the Wells G & H Remedial Investigation to characterize the extent and degree of contamination at the site, identify potential source areas, and provide data for the Feasibility Study. Through the installation of groundwater monitoring wells and subsequent sampling and analysis, NUS/FIT has demonstrated

that four areas of groundwater contamination exist in the Wells G & H aquifer area. Separate plumes of volatile organic groundwater contamination have been linked to the W.R. Grace property and the UniFirst Corporation property. An area of volatile organic groundwater contamination has been linked to the Wildwood Conservation Corporation property and a separate area of groundwater contamination has been identified in the northwest corner of the study area. On the basis of groundwater flow, the source of the latter area of contamination in the northwest corner of the study area is likely northwest of well location S75. However, the exact source area can not be identified due to the lack of data in that area. Contamination of groundwater underlying the Juniper Development Group property may be due to past site activities.

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